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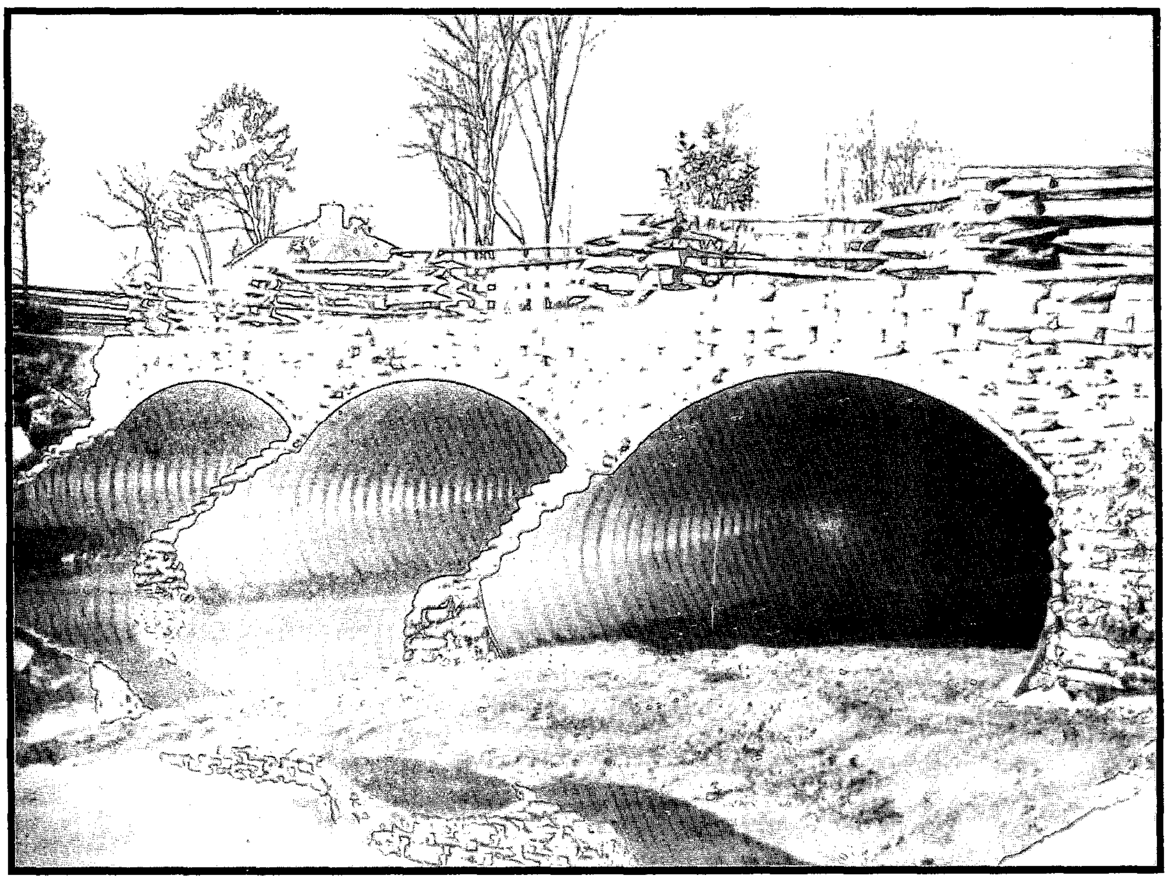
REGIONAL STORMWATER MANAGEMENT STRATEGY
FOR SOUTHEASTERN VIRGINIA



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Virginia Coastal Zone Management Program

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REGIONAL STORMWATER MANAGEMENT STRATEGY FOR SOUTHEASTERN VIRGINIA

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Prepared by the Staff of the
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EXECUTIVE SUMMARY

Nonpoint Source (NPS) Pollution, the transfer of pollutants from land to water during rainfall events, can result in severe, widespread water quality degradation. This study focuses on NPS pollution in developed and developing areas. Primary NPS pollution problems in such areas include sedimentation from construction activities, fertilizer and pesticide runoff, malfunctioning septic and sanitary sewer systems, motor vehicle emissions, improperly disposed of household hazardous wastes, runoff from industrial land use, and roadway deicing. These problems are aggravated by increases in impervious surface areas, which lead to greater runoff rates and volumes, and NPS pollutant export.

Following enactment of the 1972 Clean Water Act, federal and state water quality management efforts emphasized point source pollution. Recently, understanding of and concern for the impacts of NPS pollution has increased. This is reflected in the Water Quality Act (WQA) of 1987 which significantly increases federal involvement in NPS pollution control. Section 319 of the WQA requires states to prepare NPS problem assessment reports and four-year NPS management programs. Section 405 directs EPA to develop a permitting program for industrial and municipal stormwater discharges.

The State of Virginia has also increased its NPS management efforts. Recent initiatives include preparation of the Virginia Nonpoint Source Pollution Management Program which is the management program required by the 1987 WQA; an amendment to the Erosion and Sediment Control Law requiring local programs to address water quality as well as erosion and flooding during construction activities; and, most significantly, the passage of the Chesapeake Bay Preservation Act (CBPA). The CBPA is a deviation from the state's voluntary, non-regulatory approach to NPS control. The CBPA requires Tidewater localities to (1) designate Preservation Areas which, if improperly developed, would lead to water quality degradation, and (2) to incorporate measures into their land use controls to protect these areas and water quality.

This report attempts to assist Southeastern Virginia localities to develop effective stormwater management programs for developed and developing areas consistent with federal and state NPS control initiatives, particularly the EPA stormwater permitting program and the CBPA. To fulfill this objective, this report evaluates the impact on local governments of state and federal NPS management activities, the impacts of NPS pollution on critical aquatic resources, and alternative NPS control techniques. NPS loadings are estimated and control strategies developed for typical watersheds. Finally, a regional management strategy is recommended.

FEDERAL AND STATE INITIATIVES IN STORMWATER MANAGEMENT

This chapter discusses the evolution and current status of the federal NPS and urban stormwater management strategies. The NPS management provisions of Sections 208 and 305(b) of the 1972 CWA and Section 319 of the 1987 WQA are summarized. The background and contents of the stormwater permitting provisions in Section 405 of the WQA are described in detail. The EPA permitting regulations are summarized in Appendix A.

State initiatives include the State Water Control Law as it applies to NPS management; existing state NPS management activities mandated by the federal WQA under Sections 208, 319 and 405; the Erosion and Sediment Control Law; the Chesapeake Bay Nonpoint Source Pollution Control Program; the CBPA and implementing regulations (contained in Appendix B); and recent legislation enabling the establishment of local stormwater management programs.

The implications for local governments of the Section 405 stormwater permitting regulations, the Section 319 Nonpoint Source Pollution Management Program, and the CBPA are discussed. Only Virginia Beach, Norfolk, Chesapeake and Portsmouth are subject to the stormwater permitting regulations. Smaller localities are currently exempt, but will most likely be subject to regulations to be issued in 1992. Critical issues for local governments in meeting the permitting regulations include the EPA's definition of municipal storm sewer systems, and the cost and manpower required to comply with the permitting requirements. The local programs and strategies, recommended in the Nonpoint Source Pollution Management Program, are not mandatory. They may be used, however, to fulfill the regulations developed under Section 405 of the WQA and the CBPA. By allowing considerable state involvement in the development of local land use control programs, the CBPA has potentially significant implications for local governments.

THE EFFECTS OF NONPOINT SOURCE POLLUTION ON CRITICAL AQUATIC HABITAT

Five types of critical aquatic habitat that are susceptible to NPS pollution impacts have been identified. They include wetlands, submerged aquatic vegetation (SAV) beds, spawning grounds, nursery areas and shellfish beds. Appendix C contains a preliminary regional inventory of these habitat types.

Wetlands are extremely productive and provide food and shelter for many resident and migratory fish and wildlife. Wetlands can reduce the adverse effects of NPS pollution by filtering runoff before it reaches the open water. However, the ability of wetlands to perform a pollution control function is limited. Once the limit is exceeded, the productivity of wetlands will deteriorate.

SAV includes all rooted and unrooted underwater plants. It serves as cover, food source, spawning ground and nursery area for many species of fish and invertebrates. It also serves as a primary food source for many species of migratory waterfowl. SAV filters and traps sediments, accumulates nitrogen and phosphorus, and produces dissolved oxygen. Excessive sediment loads and nutrient-induced algal blooms attributable to NPS pollution limit photosynthesis.

Spawning grounds are areas in which the eggs of finfish and shellfish are released and larval development occurs. A number of fish species spawn in the waters of Southeastern Virginia. NPS pollution can eliminate suitable spawning grounds, disrupt the delicate balance of environmental conditions required by newly hatched larvae, or introduce toxics which can have lethal or sublethal effects on larvae.

Nursery areas are aquatic habitats where the initial growth and development of finfish and shellfish occurs. Finfish nurseries are usually shallow, have organic bottoms, and are often associated with wetlands or SAV beds. NPS pollutants may eliminate wetlands and SAV beds, lower dissolved oxygen levels, introduce toxics, clog the gills of juvenile fish or invertebrate food sources, or significantly lower salinity levels through the introduction of excessive quantities of freshwater.

Most shellfish are generally found in densely populated beds. In Southeastern Virginia, commercially important species of shellfish include the eastern oyster and the hard clam. Shellfish are particularly susceptible to NPS pollution because they are immobile and unable to escape unfavorable water quality conditions. NPS pollution may blanket shellfish beds with sediment, lower dissolved oxygen levels, introduce toxics that adversely affect the physiological processes of shellfish, lower salinities with excessive discharges of freshwater, and contaminate the shellfish beds with bacteria or toxics that are harmful to humans.

INVENTORY OF NONPOINT SOURCE CONTROL TECHNIQUES APPLICABLE TO MUNICIPAL STORMWATER SYSTEMS

Non-structural and structural controls, and institutional strategies which may be appropriate components of local stormwater management programs are described and evaluated. Non- structural controls include a variety of land use and vegetative controls, as well as various maintenance, inspection and education programs. Structural controls generally include impoundment, infiltration and treatment devices. Institutional strategies include a wide range of government programs which require, encourage or guide the implementation of non-structural and structural controls.

Each non-structural and structural NPS control technique identified in the inventory is evaluated with respect to its ability to control the quantity and quality of runoff, its applicability to different types and sizes of development, and to other selection considerations.

AN ANALYSIS OF NONPOINT SOURCE POLLUTANT LOADINGS IN THIRD-ORDER DRAINAGE BASINS

Annual NPS loadings for conventional pollutants, nutrients and selected metals were estimated for the region's developed and developing watersheds. The loading factors used in this analysis were developed for specific land use categories from sampling and computer modelling work done in previous studies for the Hampton Roads area, Northern Virginia and the Chesapeake Bay Basin. The estimated loadings for each basin can be found in Appendix D. A summary of those drainage basins producing high NPS loadings is also provided.

To demonstrate the magnitude of the NPS pollution problem, estimated NPS loadings from the Lynnhaven River Basin and discharges from a hypothetical sewage treatment plant (STP) having the capacity to serve the total population within that basin were compared. This analysis indicates that NPS Biochemical Oxygen Demand loadings would be on par with STP loadings, and that NPS total suspended solids, lead and zinc loadings would far exceed those for STPs. STP loadings for total nitrogen and total phosphorus would exceed NPS loadings. Even for these parameters, nonpoint sources would account for a significant proportion of total loadings (24% and 35% respectively). Since there are no actual STP discharges to the Lynnhaven River, NPS pollution is the primary contributor to water quality degradation in this water body.

STORMWATER CONTROL STRATEGIES FOR TYPICAL FOURTH-ORDER WATERSHEDS

In order to evaluate and develop NPS strategies on a small scale, typical fourth-order drainage basins representing varied mixes and densities of land uses were identified. Annual NPS loadings were estimated for each of these watersheds and compared to loadings that could be expected from a hypothetical one (1) MGD STP. Control strategies recommended for each watershed were selected from the inventory of techniques presented in Chapter III.

STORMWATER MANAGEMENT STRATEGY FOR SOUTHEASTERN VIRGINIA

The Regional Stormwater Management Strategy is a tool to assist local governments in developing effective stormwater management programs that not only satisfy state and federal requirements, but also take full advantage of the authority granted to local governments under the Virginia State Code. The Regional Strategy is divided into four categories: (1) stormwater impact monitoring, (2) institutional initiatives, (3) non- structural controls and (4) structural controls.

Stormwater Impact Monitoring

It is recommended that the impact monitoring requirements of the proposed EPA stormwater permitting regulations be implemented. These requirements include local source identification and discharge characterization programs. Source identification programs would locate major outfalls, delineate drainage basins, and identify land uses, natural features and activities which may affect the quantity and quality of runoff. Discharge characterization programs would include illicit discharge screening, representative sampling, and estimates of pollutant loadings and concentrations. Some elements of these programs might best be accomplished through a regional, cooperative approach.

Institutional Initiatives

Institutional initiatives include those required under the CBPA and the EPA stormwater permitting regulations, and those that may support and reinforce the state and federal requirements, but are not mandatory. Under the CBPA, Tidewater localities will be required to institute the Chesapeake Bay Preservation Area designation and protection criteria contained in the implementing regulations. The EPA stormwater permitting regulations will require a local program through which industrial facilities must provide certification to municipalities that their runoff has been tested for non-stormwater discharges and/or is in compliance with NPDES permits. The regulations also require a local program to ensure that all non-stormwater discharges are either removed or are covered by separate NPDES permits.

Non-mandatory initiatives include the adoption of stormwater management ordinances; revision of site plan review procedures; improved enforcement of erosion and sediment control ordinances; institution of on-site sewage management districts; the adoption of tree preservation ordinances; reduction of property tax assessment on land used for NPS control; and use of enabling legislation which allows localities to require developers to share the cost of off-site drainage facilities.

Non-structural Controls

Non-structural controls are generally preferred over structural controls when comparable benefits will be achieved. Many locally appropriate non-structural controls are required or suggested in the CBPA regulations. Localities should consider implementing the non-structural controls detailed in the CBPA regulations in areas outside of the designated Preservation Areas and outside of the Chesapeake Bay watershed.

Other recommended non-structural controls include a routine inspection and maintenance program for structural controls; development of regional design and performance criteria for structural controls; establishment of educational programs encouraging residents and businesses to implement measures to reduce NPS pollution; and an increase in the frequency of vacuum street sweeping in industrial and commercial areas.

Structural Controls

Structural controls are recommended for both developed and developing areas. Infiltration devices are not generally recommended in Southeastern Virginia due to high water tables, inadequate soil permeability and high maintenance requirements.

Recommended controls in developed areas include retrofitting existing wet detention basins with extended detention devices and incorporating appropriate pollution control devices into local stormwater conveyance systems. In developing areas, recommended controls include wet detention basins, pervious pavement in low volume traffic areas, and activity-specific controls for new development involving outside material and/or hazardous materials and waste storage.

INTRODUCTION

THE NONPOINT SOURCE POLLUTION PROBLEM

In recent years, increasing attention has been paid to the problem of nonpoint source (NPS) water pollution. NPS pollution is generally defined as the transfer of pollutants from land to water during rainfall events. This transfer occurs directly as sheet runoff or indirectly through a stormwater collection system. NPS pollution can result in severe and widespread water quality degradation. The 1989 Virginia Nonpoint Source Assessment Report found that 4,294 miles of the state's freshwater rivers and 489 square miles of its tidal estuaries have identifiable water quality impacts attributable to NPS pollution. For approximately 18 percent of these waters, water quality standards are not met. NPS pollution problems are of particular concern in developed and developing urban areas. In such areas, pollutants from a variety of human activities are deposited on or beneath the ground and washed into receiving waters with precipitation. These pollutants and their primary sources include:

- sediments from construction activities;
- nutrients from fertilizer runoff;
- pathogenic microorganisms and oxygen demanding substances from domestic animal droppings and malfunctioning septic and sanitary sewer systems;
- toxic substances from motor vehicle emissions, pesticide application, improperly disposed household hazardous wastes, and runoff from industrial land use;
- oil and grease from motor vehicles; and,
- chlorides from roadway deicing chemicals.

The effects of man's activities are aggravated by the increase in impervious surface areas associated with urbanization. Impervious areas (streets, parking lots, sidewalks, rooftops and so forth) allow for little retention or infiltration of runoff. This drastically increases runoff rates and volumes which may cause downstream erosion, flooding, and increased NPS pollutant export to receiving waters.

BACKGROUND

In the past, water quality management efforts focused on point sources of pollution. Point source pollution involves the continuous discharge of pollutants through a pipe and is generally associated with discharges from factories and sewage treatment plants. As a result of the emphasis placed on point source control in the 1972 Clean Water Act (CWA), considerable progress has been made in mitigating water quality problems associated with point sources. The 1972 CWA established a nationally coordinated permit program, the National Pollutant Discharge and Elimination System (NPDES), which regulates discharges from discrete point sources such as municipal sewage treatment plants, factories, mines and feedlots. In addition, the Act authorized the federal government to provide funds for the construction and upgrading of municipal sewage treatment plants. The purpose of these programs was to ensure that all point source discharges meet effluent limitation guidelines established by the U.S. Environmental Protection Agency (EPA). Although the 1972 CWA required that NPS pollution be addressed in the water quality planning process mandated by Section 208, the Act contained no specific regulatory provisions relating to NPS control.

In the years following the enactment of the 1972 CWA, the development and implementation of Section 208 state and areawide water quality management plans brought NPS pollution problems to light and encouraged the development of management and control measures, known as Best Management Practices (BMPs). During the same time, the EPA was mandated by the courts to regulate separate storm sewer discharges through the NPDES program. This began a long and controversial attempt to develop stormwater permitting regulations. In response to the increasing concern about NPS pollution and the need to provide guidance in the development of a stormwater permitting program, the EPA initiated the National Urban Runoff Program (NURP) in 1978. The purpose of the NURP was to determine the extent to which urban runoff contributes to water quality degradation and to evaluate the effectiveness and affordability of BMPs. The findings of the NURP, published in 1983, indicated that urban runoff can significantly contribute to water quality problems and that certain BMPs can effectively reduce NPS problems.

Due to the improved understanding of NPS pollution problems and the difficulties encountered by the EPA in developing stormwater permitting regulations, the 1987 Water Quality Act (WQA) significantly increased federal involvement in NPS control. Section 319 of the WQA requires each state to prepare a report assessing its NPS problems and to follow this report with the preparation of a four year NPS management program. New stormwater discharge permitting provisions are contained in Section 405 of the Act. These provisions direct the EPA to promulgate final stormwater permit regulations in accordance with specific guidelines. Initially these regulations would apply to discharges associated with industrial activity and municipal storm sewer discharges serving populations of 100,000 or more. Draft regulations were published in December 1988 and are currently undergoing public review. The EPA anticipates that the final rule will be promulgated in early 1990.

As a result of its Section 208 planning program, the State of Virginia's role in the management of NPS pollution increased significantly during the 1970s. In accordance with the provisions of Section 208, the state elected to take a voluntary, non-regulatory management approach for those nonpoint pollution sources not already controlled by regulatory programs. In keeping with this approach and through the Section 208 planning program, the State Water Control Board produced a series of BMP handbooks in 1979 which served as the core of the state's NPS management program.

An exception to the state's non-regulatory approach was the passage in 1973 of the Erosion and Sediment Control Law (ESCL). The ESCL required local governments to develop programs to minimize soil erosion and runoff during construction activities. Initially, the ESCL only addressed erosion and flooding concerns, and not water quality. This changed in 1988 when the Law was amended to require local erosion and sediment control programs to address water quality degradation in addition to erosion and flooding.

The state currently retains its voluntary, non-regulatory NPS management program. This approach is reflected in the Virginia Nonpoint Source Pollution Management Program which is currently in draft form and is undergoing public review. This program, which serves as the state's four year management plan as required by Section 319 of the WQA, identifies statewide management goals and programs for eight categories of NPS pollution. In a related non-regulatory initiative, the 1989 Virginia General Assembly increased the authority of local governments to deal with NPS pollution by passing legislation which enables localities to establish stormwater management programs. Such programs would require the submission and approval of stormwater management plans prior to most development activities.

In the Tidewater area, there has recently been a major deviation from the state's non-regulatory NPS management approach. The 1988 Virginia General Assembly passed the Chesapeake Bay Preservation Act (CBPA) which substantially increases state authority over the control of local land use in the Chesapeake Bay watershed. The CBPA was passed in recognition of the contribution of NPS pollutants to water quality problems in the Bay and the need for stronger land use controls to manage these pollutants. The CBPA requires Tidewater localities to designate Preservation Areas which, if improperly developed, would lead to water quality degradation, and to incorporate measures into their comprehensive plans and land use controls (zoning ordinances and subdivision ordinances) to protect these areas. The Chesapeake Bay Local Assistance Board (CBLAB) has proposed criteria for identifying Preservation Areas and developing land use control measures. These criteria are currently under public review and must be formally adopted by the CBLAB by July 1, 1989. Local Preservation Areas and revised land use controls will be subject to review and determination of consistency with the Act by CBLAB.

PURPOSE OF STUDY

The purpose of this study is to assist Southeastern Virginia localities in developing effective stormwater management programs that meet the requirements of state and federal NPS pollution control initiatives, particularly the Section 405 stormwater discharge permitting program and the Chesapeake Bay Preservation Act. This study encompasses urban and urbanizing areas in Southeastern Virginia located outside of the Elizabeth River basin. Stormwater management in the Elizabeth River basin is addressed in the <u>Elizabeth River Basin Environmental Management Program</u> which was prepared concurrently with this study by the SVPDC and the Hampton Roads Water Quality Agency.

It is the intent of this report to provide guidance in the development of urban stormwater management strategies which not only provide water quality benefits, but are consistent with the legal and administrative capabilities, the financial resources, and the physical constraints and opportunities of the region's localities. To realize this objective, this report is comprised of the following components:

- A background and summary of federal and state regulatory and non-regulatory NPS management initiatives and the implications of these initiatives for local governments (Chapter I).

- A discussion of possible impacts of NPS pollution on critical aquatic habitat. A preliminary critical habitat inventory was prepared which will serve as a starting point for a more comprehensive effort in the future (Chapter II).

- An inventory and evaluation of non-structural BMPs, structural BMPs and alternative institutional strategies (Chapter III).

- An analysis of the magnitude of NPS pollutant loadings in the region's developed and developing areas. This analysis includes estimated loadings for each of the region's third-order drainage basins and a comparison of basin-specific NPS loadings with loadings from a hypothetical sewage treatment plant (Chapter IV).

- An analysis of NPS loadings and the development of stormwater control strategies for seven representative fourth-order watersheds containing typical mixes and intensities of land use (Chapter V).

- The development of a regional stormwater strategy containing recommendations for implementation at the local level which will assist local governments in developing effective stormwater management programs that meet federal and state requirements (Chapter VI).

CHAPTER I

FEDERAL AND STATE INITIATIVES IN STORMWATER MANAGEMENT

This chapter contains a general overview of the federal and state nonpoint source strategies and legislation, and a more detailed discussion of the federal approach to urban stormwater management including the EPA's National Pollutant Discharge Elimination System (NPDES) stormwater permitting program.

OVERALL FEDERAL NONPOINT SOURCE STRATEGY

Except for the NPDES stormwater permitting regulations and legislation regulating other specific categories of runoff (such as from mining operations), the federal approach to the general nonpoint source (NPS) problem has been largely indirect in nature. The actual control of NPS pollution has been left primarily to the states. The EPA has taken the position that only at the state, areawide and local levels is there "enough flexibility and the ability to make site-specific and source-specific decisions necessary for implementing effective NPS management programs".[1]

Despite this indirect approach, the 1972 Clean Water Act (CWA [adopted as the Water Pollution Control Act Amendments of 1972, P.L. 92-500]) contained two provisions, which are still in effect and which gave the federal government a certain amount of influence in guiding the development of state and local NPS management programs. Under Section 208 of the Act, state governments are required to identify areas with substantial water quality problems and to designate areawide planning agencies responsible for developing effective areawide waste treatment management plans. The state water quality planning agency (the Virginia State Water Control Board [SWCB] in Virginia) is also required under Section 208 to prepare a statewide waste treatment management plan to cover "undesignated" areas not served by areawide planning agencies. The areawide and statewide plans, which must be approved by the EPA, are required to identify significant NPS sources of pollution and procedures and methods to control them. EPA regulations published to govern the preparation of Section 208 plans clarified the NPS provisions by requiring that plans "describe the regulatory and non-regulatory programs, activities and Best Management Practices which the agency has selected as the means to control nonpoint source pollution where necessary to protect or achieve approved water uses".[2] Amendments to Section 208 in 1977 CWA (P.L. 95-217) established an agricultural NPS control program (Rural Clean Water Program) through which rural land owners and operators are eligible for federal financial assistance for NPS control. Although the Section 208 provisions remain in effect, the areawide planning process has come to a near standstill due to a severe decrease in federal funding assistance. A few areawide agencies are still active, however, through local funding efforts.

In addition to Section 208, Section 305(b) calls upon each state to submit to the EPA a biennial report describing the quality of the state's navigable waters and the feasibility and practicality of attaining the water quality goals of the Act. The 305(b) report serves as a State's primary problem assessment and directs continuing planning and implementation activities. These reports are required to contain a "description of the nature and extent of nonpoint source pollution and recommendations of programs needed to control each category of nonpoint sources, including an estimate of the costs of implementing such programs."[3]

The 1987 Water Quality Act (WQA [P.L. 100-4]) significantly increased the federal role in NPS pollution control. Until enactment of this Act, the primary focus of federal water quality legislation had been the control of point source discharges. As knowledge of the magnitude of the NPS pollution increased, however, it became clear that the NPS problem had not been adequately addressed in previous federal legislation. Despite the new emphasis on NPS pollution problems, the 1987 WQA continues to leave primary responsibility for NPS pollution management in the hands of the states.

The most important provision of the 1987 WQA pertaining to NPS control is Section 319. This provision requires each state to prepare a State Assessment Report which identifies waters that cannot attain or maintain water quality standards or other WQA requirements without additional NPS control measures. This report is also required to identify the categories of NPS pollution, or specific nonpoint sources, which contribute to the pollution problems in the waters identified as problem areas. The State Assessment Report can be used to fulfill the requirements of Section 305(b) of the 1987 WQA as they pertain to a description of the nature and extent of nonpoint sources of pollution. The State Assessment Report is to be followed by the development of a four year State Management Program to reduce pollutant loadings from the NPS categories and specific nonpoint sources identified. The Program must also identify Best Management Practices (BMPs) and programs for implementing BMPs which are necessary for reducing pollutant loadings. Both the Assessment Report and the State Management Program were to be completed by August 4, 1988 and require EPA approval. An annual report to the EPA summarizing the progress made in implementing the program is also required.

The 1987 WQA also provides for financial assistance to states for controlling NPS pollution. Federal grants and loans are available for a variety of NPS management activities including preparation of state NPS Assessment Reports, preparation and implementation of NPS Management Programs, and assistance to states which fail to submit or obtain EPA approval for their management programs.

FEDERAL URBAN STORMWATER MANAGEMENT STRATEGY

The origins of existing federal efforts to control urban stormwater runoff lie in the Water Quality Act of 1965 (P.L. 89- 234). Section 62 of this Act authorized the Federal government to make grants for the purpose of "assisting in the development of any project which will demonstrate a new or improved method of controlling the discharge into any water of untreated or inadequately treated sewage or other waste from sewers which carry stormwater or both stormwater and sewage or other wastes,...".[4]

The 1972 CWA placed new and stronger emphasis on controlling urban runoff. As discussed above, reports required under Sections 208 and 305(b) of the Act were required to address NPS pollution. In addition, under Section 201, stormwater facilities were added to the definition of "treatment works" thus making projects for the abatement of stormwater pollution eligible for general construction grants even if new technology is not involved.[5]

As Section 208 areawide water quality management plans were developed, uncertainties mounted regarding the nature and extent of urban runoff water quality problems and the effectiveness and affordability of BMPs. Because of these uncertainties, the 1977 CWA deleted federal funding for separate stormwater treatment works. It was determined by Congress that there was not enough known about the effects of urban runoff on water quality to warrant making investments in physical control systems. In response to these concerns, the EPA initiated the Nationwide Urban Runoff Program (NURP) in 1978. The overall goal of the NURP was to assist local decision makers, states, EPA, and other interested parties in determining whether urban runoff is causing water quality problems. In the event that it is, the findings of the NURP would provide guidance in postulating realistic control options and developing water quality management plans that would lead to implementation of least cost solutions. It was also hoped that the NURP findings would contribute to the formulation of policy which would help determine the role of federal, state and local parties in the control of urban stormwater runoff. The conduct of NURP studies included (1) a careful review of what was then known about urban runoff and its control; (2) the provision of technical, financial and management assistance to 28 areawide agencies in the process of preparing urban runoff elements of formal water quality management plans; and (3) the collection and analysis of data resulting from these areawide projects.

Findings from the NURP studies indicated that, although the effects of urban runoff are highly site-specific, urban runoff can be a significant contributor to the degradation of water quality. The studies also found that certain management practices can be effective in reducing the negative impacts of urban runoff. The NURP studies' findings were instrumental in guiding EPA policy decisions during the lengthy and controversial process of establishing permitting priorities, and permit conditions and limitations, for the EPA NPDES Stormwater Permitting Program. This program is discussed in detail below.

THE EPA URBAN STORMWATER PERMITTING PROGRAM

A major exception to the federal government's indirect approach to NPS pollution control is EPA's urban stormwater permitting program. The following describes the evolution and current status of this program.

Background

The 1972 CWA established the basis for the development of limitations on point source discharges to all surface waters. This led to the development and implementation of the NPDES permitting program. According to the 1972 CWA, a "point source" is defined as follows:

> "...any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged."[6]

From this definition, it is clear that the intent of the 1972 CWA was to give the federal government authority to regulate point source discharges from all artificial drainage facilities, including stormwater outfalls. However, the NPDES permit regulations promulgated by the EPA in 1973 exempted certain sources, including stormwater runoff uncontaminated by industrial or commercial activity, from regulation as point sources. EPA argued that it was better to prevent the introduction of pollutants into the stormwater than to control it through typical "end of the pipe" techniques. It was also concerned that the administrative burden associated with permitting all stormwater runoff discharges would be too great for agency resources.

Shortly after the 1973 stormwater permitting regulations were promulgated, the Natural Resources Defense Council (NRDC) challenged the EPA's authority to exempt certain categories of stormwater point sources from the NPDES permit requirements. In a 1975 decision, the U.S. District Court for the District of Columbia held that the EPA could not legally exempt discharges which fell within the 1972 CWA definition of point source from the NPDES permit program.

In response to the 1975 court decision, the EPA developed regulations which required NPDES permits for all stormwater discharges meeting the EPA's definition of point source. These regulations were first published in 1976. Under these regulations, a stormwater point source was defined as any conveyance primarily used for collecting stormwater which is (1) located in any "urban area" as designated by the Bureau of the Census, (2) designated by the Director on a case-by-case basis, or (3) used to discharge runoff from industrial or commercial activities. Any stormwater conveyance not fitting into any of these categories was not considered a point source and therefore not subject to the NPDES permitting process. Initially, individual permit applications were required only for stormwater discharges contaminated by industrial wastes. Discharges uncontaminated by industrial wastes were to be covered by "general" or group permits. However, in 1979 and 1980, comprehensive revisions to the stormwater regulations were published which required individual permit applications for all stormwater discharges defined as point sources.

The 1976 regulations, as revised, were again challenged in court, this time by industry representatives. The litigants argued that the EPA had not gone far enough in exempting stormwater dischargers from the NPDES program and that permit application testing requirements were inappropriate and unduly burdensome. After almost two years of litigation and negotiations, the EPA signed a settlement agreement with the litigants in which the EPA agreed to issue a proposal for new regulations in 1982. Under the 1982 proposal, the definition of a stormwater point source was significantly narrowed to include only stormwater discharges that are either (1) contaminated by contact with process wastes, raw materials, toxic pollutants, specific hazardous pollutants listed by the EPA, or oil and grease; or (2) designated as a stormwater discharge by the Director. In addition, the proposal included a number of provisions for less rigorous testing and application procedures. The most significant of these provisions divided stormwater discharges defined as point sources into two groups. The first group (Group I) identified dischargers which were more likely to pose significant pollution problems and should therefore be subject to more sampling and application requirements. Group II dischargers, which included all stormwater point sources not included in Group I, would be subject to less vigorous application requirements and no sampling requirements because their associated pollution problems were considered less significant than those of Group I.

EPA's 1982 proposal generated considerable comment and controversy. In general, industries and trade associations asserted that the proposed regulations still had not adequately restricted the definition of stormwater point sources and questioned whether the EPA had a legally sound and technically supportable basis for the Group I and Group II designations. States and environmental groups, on the other hand, argued that the EPA went too far in narrowing the scope of coverage. After giving consideration to the comments received, EPA's final regulations, which were published in 1984, revoked the definition of stormwater point sources presented in the 1982 proposal and retained the definition contained in the pre-existing regulations. Most of the provisions in the 1982 proposal for simplifying the sampling and application procedures were incorporated into the final rule, however. Most significantly, the two-tiered approach was adopted. In addition, under the 1984 final rule, the operator of a publicly-owned separate storm sewer system could either apply for one general permit for all stormwater point sources discharging into its system, or decline responsibility for non-municipal discharges into its system thus forcing such discharges to be covered by individual NPDES permits.

Following the promulgation of the 1984 regulations, law suits were once again filed by industries and trade associations. In their challenges, these groups claimed that the six month deadline for the submission of NPDES permit applications was too strict, and that the Group I sampling requirements were excessive. They felt that the EPA would be overwhelmed by the large amount of data submitted by individual dischargers under the Group I sampling requirements and that most data would be outdated by the time permits were issued. They also objected to the expense of sampling when the data would not be used in a timely manner. In response to these criticisms, the EPA proposed new rules in two notices issued in 1985 which suggested new permit application deadlines and new procedures for the collection and analysis of Group I sampling data.

The 1985 notices again proposed group permit applications, this time for narrowly defined categories or subcategories of Group I industrial dischargers. It was envisioned that the approval of group permit applications would be based on representative discharge data, submitted by trade associations or other appropriate entities, from individual industrial facilities within each of the categories or subcategories. The EPA regarded the submission of group applications as the most practical and efficient means of establishing permit terms, conditions and priorities given the extremely large number of industrial stormwater discharges requiring NPDES permits. Group I dischargers who were either not eligible for inclusion in one of the categories defined by the EPA or who chose not to participate in a group application process would be required to submit individual permit applications and be subject to the sampling requirements contained in the 1984 regulations.

The 1985 notices also requested comments on whether publicly-owned separate storm sewer systems should be classified as Group I or Group II dischargers. The EPA, which felt that the 1984 regulations were not clear on this point, favored classifying such systems as Class I dischargers. The 1985 notices also solicited comments on a proposal that would hold operators of publicly-owned separate storm sewer systems responsible for all municipal and non-municipal stormwater point sources discharging into their systems. Under this proposal, operators of public systems would be required to notify the permitting authority of any Group I discharges into their systems. The permitting authority would then determine whether the Group I dischargers should be co-permittees with the municipal operator or should apply for individual permits.

The 1984 regulations established a deadline of six months from the promulgation of the regulations for the submission of NPDES permit applications for both Group I and II stormwater discharges. This set the deadline at April 26, 1985. The 1985 proposals recommended extending the deadline to December 31, 1987 for Group I applicants (both group and individual) and June 30, 1989 for Group II applicants.

The proposed regulations issued in 1985 were never promulgated. Due to the problems that the EPA was having in implementing a stormwater permitting program, Congress amended the stormwater provisions contained in Section 402 of the Clean Water Act in the course of enacting the Water Quality Act (WQA) of 1987. As discussed below, the 1987 WQA requires the EPA to promulgate new stormwater application requirements.

The Stormwater Permitting Provisions of the 1987 Water Quality Act

While the EPA was attempting to develop and refine regulations for permitting stormwater point source discharges, Congress was examining the stormwater issue in the course of the Clean Water Act Reauthorization. After nearly two years of negotiations and compromises between the House and the Senate, the 1987 WQA became law on February 4, 1987 as a result of a Congressional override of a Presidential veto. Section 405 of the WQA, which amended Section 402 of the CWA, directs the EPA to promulgate final stormwater permit application regulations in accordance with specific guidelines. These guidelines state that, prior to October 1, 1992, no permits will be required for discharges composed entirely of stormwater, except in the following cases:

1. Stormwater discharges already permitted prior to enactment of the 1987 WQA.

2. Stormwater associated with industrial activity.

3. A discharge from a municipal storm sewer serving a population of 250,000 or more.

4. A discharge from a municipal storm sewer serving a population of 100,000 to 250,000.

5. A discharge which, based on a determination by the EPA Administrator or the state, contributes to a violation of a water quality standard or is a significant contributor of pollutants to the waters of the United States.[7]

By October 1, 1992, the EPA is required to issue regulations which will (1) designate stormwater discharges, other than those listed above, which are to be regulated to protect water quality, and (2) establish a comprehensive program to regulate such discharges. These regulations will be based on the findings of two studies to be conducted by the EPA. The first study, which was to be submitted to Congress by October 1, 1988, is required to identify which additional categories of stormwater discharges will be subject to permitting after October 1, 1992, and to identify the nature and extent of pollutants in such discharges. The EPA did not meet the mandated deadline for completion of this study. As of this writing, the EPA anticipates that the final report will be submitted to Congress in the summer of 1989. The second study, which is to be presented to Congress no later than October 1, 1989, will establish procedures and methods to control these stormwater discharges to the extent necessary to mitigate impacts on water quality.

The 1987 WQA also established the following general provisions for permitting municipal stormwater discharges:

- Permits may be issued on a system or jurisdiction-wide basis.
- Permits shall include a requirement to effectively prohibit non-stormwater discharges into the storm sewers.
- Permits shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system design and engineering methods, and such other provisions as the EPA Administrator or the State determines appropriate for the control of such pollutants.[8]

1987 WQA deadlines for establishing and complying with the permit application requirements are as follows:

1. For industrial and municipal dischargers (serving populations over 250,000):
   - The EPA shall promulgate regulations setting forth permit application requirements by February 4, 1989.
   - Applications must be submitted by February 4, 1990.
   - Permits must be issued or denied by February 4, 1991.
   - Permit compliance must be attained within three years of permit issuance.[9]
2. For municipal dischargers serving populations between 100,000 and 250,000:
   - The EPA shall promulgate regulations setting forth permit application requirements by February 4, 1991.
   - Applications must be submitted by February 4, 1992.
   - Permits must be issued or denied by February 4, 1993.
   - Permit compliance must be attained within three years of permit issuance.[10]

In December, 1987, in light of the stormwater provisions of the 1987 WQA and as a result of litigation brought against the EPA by the NRDC prior to enactment of the WQA, the United States Court of Appeals for the District of Columbia remanded the 1984 regulations to the EPA for further rulemaking. The EPA has since proposed new permit application regulations in accordance with the 1987 WQA guidelines. These proposed regulations, which were published in the December 7, 1988 Federal Register (53 FR 49416), are summarized in Appendix A.

STATE INITIATIVES IN STORMWATER MANAGEMENT

Virginia's program to control NPS pollution includes a variety of interacting initiatives conducted by several State agencies. The following describes the major State NPS control initiatives.

State Water Control Law

The State Water Control Law (SWCL) provides authority to the SWCB to conduct water quality management activities in all state waters.[11] The SWCL does not specifically address NPS pollution, but authorizes the SWCB to "establish policies and programs for effective areawide and basinwide water quality control and management".[12] Because effective water quality control is impossible without NPS management, the Act implicitly provides authority for regulating NPS pollution.

Under authority granted by the SWCL, the SWCB has delegated specific aspects of the NPS program to other State agencies. Agricultural NPS management is the responsibility of the Department of Conservation and Historic Resources, Division of Soil and Water Conservation (DSWC) which administers the Virginia Agriculture Water Quality Plan. Responsibility for the management of urban runoff is divided between the SWCB and the DSWC. The SWCB is responsible for already developed urban areas, while the DSWC is responsible for those urban areas undergoing development. In developing urban areas, the DSWC promotes the use of urban BMPs through its administration of the Virginia Erosion and Sediment Control Law (discussed below) and through an education program.

In developed areas where the NPS program is administered by the SWCB, localities are encouraged to enter into a voluntary, formal agreement with the SWCB to develop and implement a program which would reduce NPS pollution. This agreement requires local governments to submit annual progress reports to the SWCB.

State NPS Management Activities Mandated by the Federal WQA

Section 208

As discussed previously, the federal NPS management strategy leaves actual control of NPS pollution to the states, but provides a regulatory framework in which this control is exercised. Section 208 of the WQA requires states to identify areas with critical water quality control problems and to designate areawide planning agencies to address these problems by preparing areawide waste treatment management plans. A statewide waste treatment management plan prepared by the SWCB was also required to cover nondesignated areas. Under Section 208, both the areawide and statewide waste treatment management plans are required to identify sources of NPS pollution, and programs, activities and BMPs needed to control them.

Under Section 208, the states are given the option of implementing a regulatory or non-regulatory NPS control strategy for those sources not already controlled by regulatory programs. In Virginia, regulatory NPS control programs have been implemented for land disturbing activities resulting from construction (through the Erosion and Sediment Control Law), for environmentally sensitive areas within the Chesapeake Bay watershed (through the Chesapeake Bay Preservation Act), and for surface mining. For other sources, Section 208 allows a non-regulatory, voluntary program as long as the program fulfills certain EPA requirements and demonstrates continued progress in achieving the water quality goals of the WQA. A process for measuring progress in achieving WQA water quality goals through NPS control activities has not been developed, however.

The SWCB elected to pursue a non-regulatory approach in its statewide NPS management program for the following reason:

> "In the absence of a demonstrated cause and effect relationship between land use activities, nonpoint source pollution, and water quality problems in State waters and also due to the lack of documentation concerning the effectiveness of BMPs to reduce nonpoint source pollution, the SWCB has elected to pursue a non-regulatory NPS control strategy for those sources not already controlled by regulatory programs."[13]

Furthermore, it was felt that a non-regulatory approach would give individual localities the freedom to establish management strategies that are specifically suited to their own NPS pollution problems.

In accordance with the NPS control requirements of Section 208 and in keeping with its non-regulatory, voluntary approach to NPS management, the SWCB prepared a series of BMP handbooks which describe appropriate structural and non-structural BMPs for Virginia. A separate handbook was prepared for each of five categories of NPS pollution: agriculture, forestry, hydrologic modifications, ground water and urban. In addition to the BMP handbooks, a Management Handbook, which describes the State's overall strategy for managing NPS pollution, was prepared. These handbooks serve as the core of Virginia's NPS management strategy. The Management Handbook was certified by the Governor and approved by the EPA Regional Administrator as the official State Nonpoint Source Pollution Abatement and Management Plan for Virginia.

Section 319

As discussed previously, Section 319 of the 1987 WQA requires each state to assess the extent and nature of its NPS pollution problem and to develop a NPS management program which addresses this problem. In response to the Section 319 requirements, the DSWC prepared a draft Virginia Nonpoint Source Pollution Assessment Report (first published in April, 1988 and revised in May, 1989) and a draft Virginia Nonpoint Source Pollution Management Program (first published in August, 1988; revised in May, 1989). As of this writing, EPA approval of these two documents is pending.

In addition to meeting the Section 319 requirements, the Assessment Report will fulfill the requirements of Section 305(b) of the 1987 WQA as they pertain to a description of the nature and extent of nonpoint sources of pollution.

The State Management Program identifies statewide management goals and programs for eight categories of NPS pollution. These categories include agriculture, forestry, construction, urban, resource extraction, land treatment and disposal, and hydrologic modifications. The DSWC has been given overall responsibility for implementing the Program. However, the DSWC will work closely with the SWCB to ensure that NPS control programs are consistent with programs required to achieve compliance with the State's water quality standards and goals, and the requirements of the 1987 WQA. Once approved by the EPA, the State Management Program will replace the State BMP Management Handbook as the official NPS management plan.

In addressing urban stormwater, the Management Program presents a number of statewide goals and objectives to be achieved in managing NPS pollution. The following is a summary of these goals:

- A 40% reduction in NPS nutrient loadings.
- The development of comprehensive State stormwater management legislation.
- The development of innovative BMP technologies.
- Revision of the Urban BMP handbook, and the development of training and information programs for State and local government personnel, the development community, the land treatment industry, and the general public.
- Development of methods to estimate urban NPS loads and the identification of urban priority watersheds.

- Promotion of local planning legislation which addresses NPS pollution and encourages the use of BMPs in identified urban priority areas.

- Provision of financial assistance for BMP implementation in identified urban priority areas.[14]

Section 405

Under Section 405, the SWCB is the EPA-designated administrator of the State NPDES permitting program. In Virginia, this program is called the Virginia Pollution Discharge Elimination System (VPDES) program. Through the issuance of permits, this program limits the quantity and quality of pollutants being discharged into state waters from point sources. Occasionally, in accordance with EPA regulations, the SWCB has issued permits on a case-by-case basis for stormwater discharges which have significant pollution impacts on receiving waters. The SWCB will have additional regulatory authority to control urban stormwater discharges once EPA has promulgated regulations governing the revised stormwater permitting provisions of Section 405 of the 1987 WQA.

Erosion and Sediment Control Law

The Erosion and Sediment Control Law (ESCL) is an exception to the State's non-regulatory, voluntary approach to NPS management. In 1973, the ESCL was passed to minimize soil erosion and runoff during construction activities. The law requires that local erosion and sediment control programs be developed and implemented by counties, municipalities or the State's soil and water conservation districts (SWCDs). Under the ESCL, any party engaging in a "land disturbing activity" must submit an erosion and sediment control plan to the local "Program Administrator" and receive approval for the plan before work can proceed. The State's primary role in the administration of local programs is the establishment by the DSWC of erosion and sediment control guidelines and standards. These guidelines and standards are presented in the Virginia Erosion and Sediment Control Handbook which was first published in 1974 and updated in 1980. Although, under the ESCL, local programs must adhere to DSWC guidelines and standards, the State does not have the authority to review program decisions issued by counties or municipalities. If a program is administered by a SWCD, the State is authorized to overturn a SWCD decision in the case of an appeal. The DSWC is authorized to request the Attorney General to take legal action should violations of the ESCL occur in any of the local programs.

Initially, the ESCL and the Erosion and Sediment Control Handbook only addressed erosion and flooding concerns related to urban runoff and did not specifically address water quality. In 1980, the Handbook was revised to incorporate guidelines and criteria for managing the quantity and quality of stormwater runoff. With this revision, the Erosion and Sediment Control Handbook was made consistent with and was given status as a second volume of the SWCB's

Urban Best Management Practices Handbook. This revision, however, was made without specific statutory authority. This was remedied in 1988 when the ESCL was amended to require that local programs be developed to "prevent the unreasonable degradation of properties, stream channels, waters and other natural resources ...".[15]

Chesapeake Bay Nonpoint Source Pollution Control Program

The 1984 General Assembly allocated funding and combined it with a grant from the EPA's Chesapeake Bay Program to initiate a cost-sharing program to control urban and agricultural NPS pollution within the Chesapeake Bay drainage area. Now in its fifth year, this program is administered by the DSWC and provides cost-sharing assistance to hire technical specialists at the local level to conduct education programs and to implement demonstration projects which test the effectiveness of urban BMPs.

Chesapeake Bay Preservation Act

In 1988, the State General Assembly passed the Chesapeake Bay Preservation Act which significantly broadens the authority of the State and local governments to manage land use and its effect on water quality. The Chesapeake Bay Preservation Act was based on the findings of the Chesapeake Bay Land Use Roundtable which was formed by the Virginia General Assembly in 1986 to address the water quality goals and priority commitments expressed in the Chesapeake Bay Agreement. The Roundtable found that NPS pollutants are a significant source of water quality problems in the Chesapeake Bay and that stronger land use controls are needed to manage these pollutants. The Roundtable also found that the State, under its Constitution, has the responsibility to take a leadership role in land use planning in order to protect its land and water resources.

The Chesapeake Bay Preservation Act authorizes all Virginia localities to exercise their land use controls (such as and zoning and subdivision ordinances) to protect water quality. It also requires Tidewater localities to designate Chesapeake Bay Preservation Areas (CBPAs) which, if improperly developed, may result in water quality degradation, and to incorporate measures into their land use controls to protect CBPAs. The Chesapeake Bay Local Assistance Board (CBLAB) was formed to implement the Act. CBLAB has proposed a set of criteria to guide local governments in designating CBPAs and in revising their land use controls to comply with the Act. These criteria are currently undergoing public review. The Act mandates that the CBLAB formally adopt these criteria by July 1, 1989. The complete text of the draft criteria can be found in Appendix B. A summary of these criteria is found below.

Chesapeake Bay Preservation Area Designation Criteria

The CBLAB has proposed dividing CBPAs into Resource Protection Areas and Resource Management Areas. Resource Protection Areas are environmentally critical areas that are found at or near the shoreline and are particularly sensitive to activities which may cause water quality and/or aquatic habitat degradation. Resource Protection Areas include:

- tidal wetlands;
- nontidal wetlands associated with tidal wetlands or tributary streams;
- tidal shorelines;
- other sensitive areas identified by local governments as requiring protection to protect water quality; and,
- vegetated buffer zones located adjacent to and landward of the above listed areas.

Resource Management Areas would be contiguous to Resource Protection Areas and include land that, if improperly developed, has a high potential for causing water quality degradation or for decreasing the functional value of Resource Protection Areas. Resource Management Areas include:

- floodplains;
- highly erodible soils, including steep slopes;
- highly permeable areas or other areas vulnerable to groundwater contamination;
- nontidal wetlands not included in Resource Protection Areas; and
- any other areas identified as needing protection to control NPS pollution.

Land Use and Development Criteria

The land use and development criteria proposed by the CBLAB consist of general performance criteria which are applicable in all CBPAs as well as specific performance criteria that are applicable only in Resource Protection Areas. Both sets of criteria address a number of land use, site design, construction, landscaping, groundwater protection and wetlands preservation issues. The general performance criteria pertaining to stormwater management are most relevant to this study and are summarized below:

- Sheet flows shall be maintained and concentrated flows avoided.

- Post-development NPS pollution loads shall not exceed the predevelopment load. This criteria may be met through one of the following methods:

  - The first one-half inch of runoff from any storm event shall be retained and released over a 24 hour period;

  - Twenty percent additional vegetated open space may be provided on-site;

  - The pro-rata share of the cost of regional BMPs may be charged to developers in lieu of meeting the above criterion;

  - Other options allowed by a locality that provide an equivalent water quality benefit.

- Redevelopment shall result in a 10% reduction in NPS pollution compared to existing NPS loads from a site.

Legislation Enabling the Establishment of Local Stormwater Management Programs

The 1989 Virginia General Assembly passed legislation enabling local governments to establish, by ordinance, stormwater management programs. Under this legislation, local governments may implement stormwater management programs which would require submission and approval of a stormwater management plan prior to any non-exempt development activity. Such a plan would have to meet requirements contained in a local stormwater management ordinance. Minimum criteria are currently being developed by the State to guide the establishment of local programs. The legislation mandates that, before adopting stormwater management regulations that exceed the State's minimum criteria, a locality must conduct a watershed management study.

IMPLICATIONS OF FEDERAL AND STATE NPS MANAGEMENT INITIATIVES FOR LOCAL GOVERNMENTS

Of the aforementioned state and federal NPS pollution control initiatives, there are three newly created programs that will have a significant affect on local governments. These include the urban stormwater permitting provisions of Section 405 of the 1987 WQA, the NPS pollution management plan prepared by the State under Section 319 of the WQA, and the State Chesapeake Bay Preservation Act. The possible local implications of each of these initiatives are discussed below.

Section 405 Urban Stormwater Permitting Program

Southeastern Virginia Localities Subject To The Proposed Regulations

Of the eight Southeastern Virginia localities, only Virginia Beach, Norfolk, Chesapeake and Portsmouth would be subject to the proposed stormwater permitting regulations for medium and large municipal separate storm sewer systems. In accordance with the provisions of the 1987 WQA, the storm sewer systems serving Virginia Beach and Norfolk are considered large municipal systems, while the systems serving Chesapeake and Portsmouth are considered medium municipal systems. The only difference in the permitting regulations for large and medium municipal systems are the compliance deadlines. The 1987 WQA mandates that the application submittal and permit issuance deadlines for large municipal systems precede those for medium systems by two years.

Stormwater systems serving Southeastern Virginia localities with populations less than 100,000 (Franklin, Suffolk and the Counties of Isle of Wight and Southampton) are exempt from NPDES permitting requirements until October 1, 1992 unless a stormwater discharge permit was issued prior to enactment of the WQA, or it is determined that a discharge contributes to a violation of water quality standards. The WQA mandates that, by October 1, 1992, the EPA must promulgate rules for regulating stormwater discharges from municipal systems serving populations less than 100,000. These rules will be based on the findings of two WQA mandated studies conducted to determine the most appropriate manner for regulating such systems.

The Delineation of Municipal Separate Storm Sewer Systems in Southeastern Virginia

The EPA proposes to define municipal separate storm sewer systems as those owned and operated by incorporated places meeting the population criteria contained in the WQA. The director of the permitting authority, however, could, on a case-by-case basis, adjust the scope and/or boundaries of a designated system to include discharges from other interrelated systems that are owned and operated by municipal entities other than the incorporated place. Such a determination would require the operators of the interrelated systems to become co-applicants for the same system-wide permit. This provision was developed primarily to address independent public entities such as flood control districts, sewer districts and county agencies which own and operate storm sewer systems within and in conjunction with systems owned and operated by incorporated places. Such public entities do not exist in the Southeastern Virginia localities subject to the proposed permitting regulations. There are at least two instances, however, that may cause the Director of the permitting authority to expand the scope of Southeastern Virginia's large and medium municipal separate sewer systems. The first instance would involve storm sewers associated with a State highway running through a regulated community. These sewers may be determined by the permitting authority to be part of a designated municipal storm sewer system. In this situation, the Virginia Department of Transportation would be a co-applicant with the incorporated place. Another instance would be a municipal system owned and operated by one locality which discharges into a system owned and operated by another locality. If designated by the permitting authority to be a single municipal system, the two localities would be required to be co- applicants for the same permit. The extent to which these two situations would occur in Southeastern Virginia will depend on the interrelationships between local storm sewer systems, and the criteria used by the permitting authority to define interrelated systems.

The proposed regulations do not specifically address the status of systems that are interrelated to municipal systems, but are owned and operated by private, non-industrial entities (private residential subdivisions, large apartment complexes, office parks and so forth).

The Cost and Manpower Required to Comply with Permitting Requirements

According to estimates developed by the EPA, the average application for a permit for all discharges from a large municipal system will require $131,200 and 8,534 hours to prepare. A permit application for all discharges from a medium municipal system would take an estimated $83,600 and 5,438 hours to prepare. These estimates only reflect the costs to prepare an application and do not include the costs that would be incurred in the implementation of the required stormwater management programs. (Recent local evaluations indicate that EPA has significantly underestimated the costs of this activity.)

The actual costs, in time and money, of permit compliance could vary significantly depending on a variety of factors including:

- The size of a system;
- The necessity of applying for permits with co-applicants;
- The degree to which a municipal system receives illicit non-stormwater discharges, or stormwater associated with industrial activity;
- The availability of the resources needed to fulfill the proposed permit application requirements (i.e., money, manpower, sampling and testing equipment, expertise, and so forth); and
- The adequacy of local legal authority and administrative capabilities needed to implement a stormwater management program that meets EPA criteria.

Specific Federal funding assistance for preparing permit applications or complying with permit conditions was not provided for in the 1987 WQA. However, the EPA is working with the United States Geological Survey (USGS) to determine the feasibility of providing USGS technical support to municipalities through cooperative funding programs. The USGS would aid municipalities in the collection of representative data required in the discharge characterization component of the permit application.

Another possibility for reducing the costs associated with permit preparation and compliance might be the establishment of a regional, cooperative stormwater management program. Such a program, which might be implemented by one or more existing regional entities (HRSD, SPSA, HRWQA or SVPDC), could provide the following benefits:

- Assistance to localities in the overall preparation of stormwater permit applications;

- A cooperative effort through which participating localities would share the cost of required discharge sampling and laboratory analysis activities. The services of a private contractor or an existing public agency (HRSD, VIMS or SWCB) might be secured for this effort;

- With the approval of the permitting authority, a regional representative sampling and monitoring program might substitute for the individual system-specific programs required in the proposed regulations;

- A regional forum through which information can be exchanged on the development and implementation of stormwater control strategies.

- A coordination of control strategies where a drainage basin is located in more than one locality.

Virginia's Section 319 Nonpoint Source Pollution Management Program

The State Nonpoint Source Pollution Management Program, required under Section 319 of the 1987 WQA, recommends a number of strategies and programs which should be undertaken by local governments to assist in NPS pollution control efforts. Because, as discussed in the preceding chapter, the State has an EPA-approved non-regulatory NPS management program, the recommended local government NPS management activities contained in the State Plan would be voluntary rather than mandatory. Section 208 of the WQA allows such an approach as long as certain EPA program requirements are met and there is demonstrated continued progress in achieving the WQA water quality goals. What is lacking, however, are criteria that can be applied at the local or state level to determine the extent to which locally implemented NPS control programs are contributing to the achievement of WQA water quality goals.

The State Program recommends local programs and strategies to reduce NPS pollution from construction activities and urban runoff. For the control of NPS pollution from construction activities, the Program recommends a number of strategies to strengthen the local erosion and sediment control programs which are required under the ESCL and administered by local governments. To prevent NPS pollution from urban sources, the Program recommends programs to manage solid and hazardous waste; to preserve trees and other vegetation; to address stormwater management problems not covered by the ESCL; and to better maintain and manage existing sewer systems. The Program also recommends a number of strategies which local governments might incorporate into their site plan reviews, capital improvement programs, zoning ordinances, subdivision ordinances and tax codes to address NPS pollution problems.

The State Program also stresses the important role that Planning District Commissions (PDCs) can play in assisting localities in local NPS management. PDC technical assistance activities related to NPS pollution control include the preparation of local comprehensive plans, and zoning and subdivision ordinances, and the conduct of water quality studies and NPS educational programs.

Chesapeake Bay Preservation Act

As previously mentioned, the Chesapeake Bay Preservation Act requires that all Tidewater localities incorporate general water quality protection measures into their comprehensive plans, zoning ordinances and subdivision ordinances. The Act also requires that Tidewater localities define and protect certain lands, called Chesapeake Bay Preservation Areas (CBPAs), which if improperly developed may result in substantial water quality degradation in the Bay or its tributaries.

Although the Act in no way limits the authority of local government to regulate land use, significant state involvement in local programs is provided for under the Act through the creation of and the powers granted to the Chesapeake Bay Local Assistance Board. The Act empowers the Board to provide financial and technical assistance to local governments for carrying out the provisions of the Act. More importantly, the Act directs the Board to establish criteria that localities must follow in delineating CBPAs and developing water quality protection strategies for use within CBPAs. The Act grants the Board exclusive legal authority to institute legal action to ensure compliance with these criteria.

The Act mandates that the CBLAB develop and adopt criteria for designating CBPAs and revising local land use controls by July 1, 1989. Localities will have one year from this date to designate their CBPAs. Draft criteria have been developed and are currently undergoing review. The Act does not set a specific time limit for the development of water quality protection strategies to be implemented within the CBPAs. However, the proposed criteria would require that local adoption of a complete local program be accomplished within two years of the effective date of the regulations.

CHAPTER II

THE EFFECTS OF NONPOINT SOURCE POLLUTION ON CRITICAL AQUATIC HABITAT

The purpose of this chapter is to discuss the impacts of NPS pollution on critical aquatic habitat types found in Southeastern Virginia. Appendix C contains a preliminary critical habitat inventory for this region.

For the purposes of this study, five types of critical aquatic habitat have been identified. These include wetlands, submerged aquatic vegetation (SAV) beds, spawning grounds, nursery areas and shellfish beds. The preliminary inventory has been divided into four categories of water bodies in which the identified critical habitat may occur. They include major receiving waters (lower Chesapeake Bay, Hampton Roads and the lower James River), major tidal tributaries, the Back Bay and free flowing rivers, and lakes. Table 1 lists the principal Southeastern Virginia water bodies falling into each of these categories, and Figure 1 is a regional map showing their relative locations.

The following describes each of the identified critical aquatic habitats and discusses how they could be adversely impacted by NPS pollution.

WETLANDS

Most simply, wetlands are transitional areas between land and water-based environmental communities. Wetlands found in Southeastern Virginia are commonly known as swamps, bogs, pocosins, marshes and mudflats. In general, wetlands are characterized by undrained wet soils, vegetation that is adapted to growing in water or saturated soils, and a periodic covering of shallow water. Wetlands can either be tidal or nontidal. Tidal wetlands, which are usually vegetated marshes or nonvegetated mudflats, are found along creeks, rivers and bays that are affected by the lunar tide. Nontidal wetlands, which, in Southeastern Virginia, are usually forested, occur along freshwater streams or lakes, in flood plains or in areas of poor drainage.

Wetlands are extremely productive habitats which provide food and shelter for many resident and migratory species of fish and wildlife. Tidal marshes are particularly productive. Marshes trap nutrients originating from both the land and water and, as a result, produce considerable quantities of plant material. As this plant material dies and decomposes, it combines with decomposed animal material to form a material rich in bacteria and microalgae known as detritus. Detritus production is the basis for a major marine food pathway. Once transported by the tide to adjacent waters or mudflats, detritus becomes a rich food source for numerous aquatic organisms. These herbivorous organisms in turn serve as food for higher order carnivores. Because of the highly productive nature of tidal marshes, many species of aquatic organisms use the waters adjacent to marshes as nurseries. Various species of marine birds, migratory waterfowl and mammals also depend on marsh systems for cover and breeding grounds, and may depend on both marshes and adjacent tidal flats for feeding areas.

Although nontidal wetlands normally do not have the productive value of tidal marshes, they do provide valuable fish and wildlife habitats. Many species of freshwater fish feed in nontidal wetlands or upon wetland produced food. Nontidal wetlands are also used as spawning and nursery grounds by a number of fish species. Even nontidal wetlands that are only seasonally flooded can be important breeding and foraging grounds for some freshwater species of fish. It has also been shown that detritus originating in bottomland hardwood forests can be important to the food chain of estuarine organisms.[16] Nontidal wetlands are also essential breeding, nesting, feeding and shelter habitats for many species of waterfowl, mammals, reptiles and amphibians.

One of the most important values of wetlands is their ability to filter runoff from land before it reaches open water. In doing this, wetlands reduce the adverse effects of nonpoint source pollution by removing and retaining nutrients, breaking down chemicals and organic wastes, and reducing sediment loads. However, the ability of wetlands to perform a pollution control function is limited. Once the limit is exceeded, the productivity of wetlands and their ability to support dependent organisms will deteriorate. This is most likely to occur when stormwater runoff has been concentrated into channels that accelerate the flow of runoff into wetlands. Toxicants in runoff, such as farm or home use herbicides, may also damage wetland areas.

SUBMERGED AQUATIC VEGETATION BEDS

Submerged Aquatic Vegetation (SAV) includes all rooted and unrooted underwater plants. Like wetlands, SAV is vitally important to aquatic ecosystems because it serves as cover, food source, spawning ground and nursery area to many species of fish and invertebrates. It also serves to maintain water clarity by filtering and trapping sediments, it acts as a nutrient buffer by accumulating large quantities of nitrogen and phosphorous, and it provides an important source of dissolved oxygen. SAV also serves as the primary food source for many species of migratory waterfowl.

TABLE 1
MAJOR WATER BODIES IN SOUTHEASTERN VIRGINIA

MAJOR RECEIVING WATERS
- Chesapeake Bay
- Hampton Roads
- James River

MAJOR TIDAL TRIBUTARIES
- Rudee Basin
- Lynnhaven River
- Little Creek
- Elizabeth River
- Nansemond River
- Chuckatuck Creek
- Pagan River
- Lawnes Creek

THE BACK BAY AND FREE FLOWING RIVERS
- Back Bay
- North Landing River
- Northwest River
- Blackwater River
- Nottoway River
- Meherrin River

LAKES
- **Norfolk In-town Reservoir System**
  - Stumpy Lake
  - Lake Smith
  - Lake Lawson
  - Little Creek Reservoir
  - Lake Wright
  - Lake Whitehurst
  - Lake Taylor
- **Norfolk Western Reservoir System**
  - Lake Burnt Mills
  - Western Branch Reservoir
  - Lake Prince
- **Portsmouth Reservoir System**
  - Lake Meade
  - Lake Cohoon
  - Lake Kilby
  - Lake Speights Run
- **Suffolk Reservoir System**
  - Ten small lakes in or near Lone Star Lakes City Park.
- **Mount Trashmore Lakes**
  - Lake Trashmore
  - Lake Windsor
- **Lake Drummond**

Source: Southeastern Virginia Planning District Commission, 1988.

Nonpoint source pollution is thought to be one of the major factors in the nonexistence or drastic decline of SAV beds in many of Southeastern Virginia's water bodies. Although nutrients are essential to the growth of SAV, the excessive quantities of nutrients often found in urban and agricultural runoff promote algal blooms which cloud the water and limit the ability of SAV to photosynthesize. Excessive sediment loads from runoff compound the problem by combining with algal blooms to further prevent the penetration of sunlight. Without sufficient light, SAV eventually dies and prime aquatic habitat is eliminated.

SPAWNING GROUNDS

Spawning grounds are those areas in which the eggs of finfish and shellfish are released and larval development occurs. In most species, spawning by the female and the subsequent fertilization of the eggs by the male occur in the same location. In a few species, such as the blue crab, fertilization occurs prior to egg release and the female migrates to the spawning grounds. Most species of marine finfish common to Southeastern Virginia spawn and spend most of their lives in the open ocean, but enter estuaries during the summer to feed. Estuarine species of finfish spend their entire lives in estuaries but may migrate to the Chesapeake Bay or the downstream areas of tributaries to spawn. The larvae of both marine and estuarine species are transported from their respective spawning grounds by tides, winds and currents to nursery areas in the upper reaches of tidal estuaries.

A number of anadromous and semi-anadromous fish species spawn in the waters of Southeastern Virginia. Anadromous fish spend their adult lives in the Atlantic Ocean, but migrate to freshwater estuaries during the spring and early summer to spawn. Anadromous fish common to Southeastern Virginia include american shad, alewife, blueback herring and striped bass. Semi-anadromous fish, such as the white perch, yellow perch and several species of catfish, live in brackish water estuaries and migrate to freshwater to spawn. Most species of semi-anadromous fish will survive and reproduce in landlocked freshwater lakes.

Most freshwater species of fish are nonmigratory and nest in protected areas along the shoreline. It is in these nests that both spawning and nursery activities occur.

NPS pollution can adversely affect the success of estuarine and freshwater spawners in several ways. First, the entire spawning process may be impossible if spawning adults are unable to find suitable spawning habitat as a result of dissolved oxygen (DO) depletion from NPS-induced nutrient enrichment. Second, the survival of fertilized eggs and newly hatched larvae requires a proper balance of a number of environmental conditions including sunlight, oxygen, water agitation, salt and chemicals, and water temperature. NPS pollution can disrupt this balance and prevent the hatching of eggs or the survival of larvae. For example, low DO concentrations resulting from nutrient enrichment may harm egg and larval development, or may alter phytoplankton communities, thus affecting the type and amount of zooplankton available as food to larvae. Surges of freshwater runoff into estuaries during major storm events may also disrupt the delicate balance required for successful spawning by lowering salinity to levels that threaten the survival of eggs and larvae. A third way in which NPS pollution can affect spawning success is by the introduction of toxic contaminants (pesticides, heavy metals and organic chemicals). Toxics in runoff can be lethal to newly hatched larvae or can induce sublethal effects including changes in swimming, feeding and predator avoidance.

NURSERY AREAS

Nursery areas are those aquatic habitats where the initial growth and development of finfish and shellfish occurs. Nursery areas for finfish are usually shallow, have organic bottom types and, as previously mentioned, are often dependent on SAV beds or wetlands for nourishment. Fish larvae of marine species are produced in the open ocean and are transported by tides, winds and currents to nursery grounds in less saline, upstream areas of tidal rivers, creeks and bays. The larvae of estuarine species of finfish, and the bluecrab, may remain in the Bay or are transported from the Bay or the downstream portions of its tributaries to upstream nurseries. The larvae of anadromous and semi-anadromous fish are transported in the opposite direction from the freshwater headwaters of estuaries to nursery areas in more saline, downstream areas. As mentioned previously, freshwater fish usually nurse their young in nests found along the shoreline. The locations of nursery areas for individual species of finfish is determined by salinity levels and the presence of food sources.

In the case of shellfish species such as the commercially important eastern oyster and hard clam, nursery areas are located in already established shellfish beds. Oyster larvae are initially pelagic but eventually attach themselves to hard substrate, usually existing oyster shells. Hard clam larvae are also initially pelagic, but, during the later stages of the larval stage, they alternate between a planktonic and benthic existence occasionally attaching themselves to firm substrate. By the time they reach the juvenile stage, they have burrowed permanently in soft substrate.

Nursery areas have been identified as critical habitat because the early life stages of shellfish and finfish are more sensitive to the adverse effects of NPS pollution than adult organisms. NPS pollution may adversely affect nursery areas in the following ways:

- Nutrient enrichment may cause algal blooms which may depress DO levels and/or cause the disappearance of SAV beds.

- Toxics carried in runoff may have lethal or sublethal effects on juvenile populations.

- Wetlands loss due to runoff may lead to the disappearance of suitable nursery habitat.

- Turbidity resulting from excessive sediment loads in runoff may cause a rise in water temperature to a point that threatens juvenile populations.

- Sediment suspended in turbid water may clog the gills of juvenile fish or the gills of invertebrates that are their food sources.

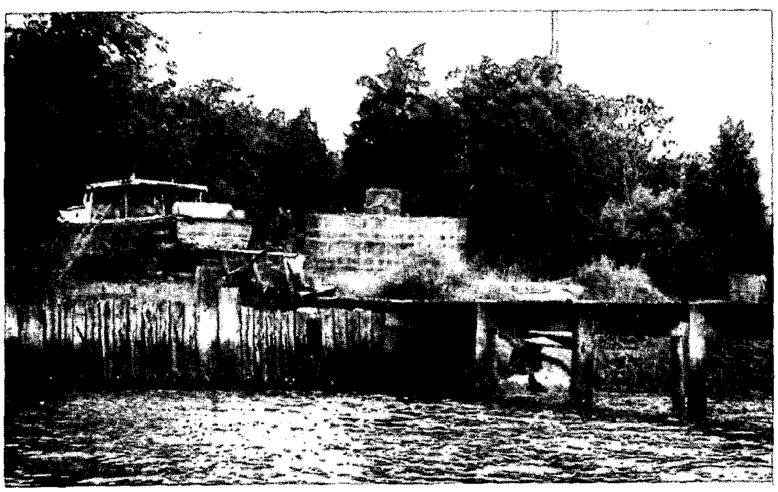
- Excessive quantities of freshwater runoff may decrease salinity levels to a point where juvenile populations are threatened.

SHELLFISH BEDS

The National Shellfish Sanitation Program Manual defines shellfish as "all edible molluscan shellfish species of oysters, clams and mussels".[17] Commercially important shellfish species harvested in Southeastern Virginia include the eastern oyster and the hard clam. Shellfish are immobile bottom dwellers that are generally found in densely populated beds. Oyster beds are found on firm bottom surfaces in relatively shallow (less than 8 - 10 meters) water with relatively low salinity. A firm substrate is required to support the massive and heavy clusters of oysters found in a bed. In the lower James River and its tributaries and in the tributaries of the lower Chesapeake Bay, oyster "reefs" comprised of shell rubble from previous oyster populations provide suitable habitat for the attachment of oyster larvae and development of mature oysters. Oyster beds are also important as "habitat modifiers" which provide habitat for a variety of benthic invertebrates which are food for commercially and recreationally important fish species such as the croaker.

Unlike the oyster which attaches itself to hard bottom surfaces, the mature hard clam burrows in penetrable bottom sediment. Hard clams require slightly higher salinities than the oyster and can be found anywhere from intertidal mudflats to depths of 10 meters or more. Hard clams, especially juveniles, are important food sources for a number of fish, crabs, water fowl and marine birds.

Oysters and hard clams are particularly susceptible to NPS pollution because they are immobile and unable to escape unfavorable water quality conditions. Sediment carried in runoff can blanket and suffocate oyster and clam beds. Sediment may also eliminate the hard, clean surfaces required for the attachment of oyster larvae. In addition, excessive nutrient loads in runoff may significantly lower DO levels. Low DO can severely stress shellfish populations thus lowering disease resistance and reproductive success. In cases of sustained DO depletion, entire beds may be eliminated. Shellfish may also be susceptible to toxics contained in NPS pollution. Contamination of bed sediments and overlying water by toxics can adversely affect the physiological processes of shellfish and possibly make them unfit for human consumption. Frequent freshwater discharge from stormwater runoff is another limiting factor to the survival of shellfish populations. Such discharges may result in long term reduction in salinity levels which could either eliminate shellfish populations or lower their resistance to disease and predation. Finally, shellfish may ingest and concentrate bacteria that is harmful to humans contained in urban runoff. Bacterial contamination is the primary reason for the condemnation of shellfish beds in Southeastern Virginia.



CHAPTER III

INVENTORY OF NONPOINT SOURCE CONTROL TECHNIQUES APPLICABLE TO MUNICIPAL STORMWATER SYSTEMS

Techniques to prevent or reduce adverse water quality impacts from stormwater runoff include both Best Management Practices (BMPs) and institutional strategies. BMPs are defined by the EPA to include structural and non-structural controls, and operation and maintenance procedures.[18] For the purposes of this study, non-structural controls include land use controls, vegetative controls and various maintenance, inspection and educational programs. Structural controls generally include a variety of impoundment and infiltration devices. Institutional strategies include government programs which require, encourage or guide the implementation of BMPs.

The EPA's proposed stormwater permit application procedures are structured to encourage localities to develop flexible stormwater management programs comprised of a broad mix of control techniques which address locality-specific NPS problems. For instance, a program designed for an already established urban area will differ significantly from one designed for a developing community. The former would most likely consist of maintenance, inspection and educational programs and possibly strategies to retrofit existing stormwater collection systems with structural controls. The latter might favor land use controls and requirements to incorporate structural BMPs into new developments.

The Virginia Nonpoint Source Pollution Management Program presents a number of urban NPS management goals. The Program also encourages local governments to incorporate a variety of control strategies, which would promote achievement of these goals, into their stormwater management programs. In keeping with the State's voluntary, non-regulatory approach to NPS management, these strategies are recommended and not required.

The following inventory briefly describes a number of non-structural and structural controls, and institutional strategies which should be considered in the development of urban stormwater management programs. The locality-specific stormwater management programs required by EPA's proposed stormwater permitting regulations will most likely be comprised of an appropriate mix of the techniques contained in this inventory. Later in this report, this inventory is used to recommend stormwater management strategies for typical fourth-order drainage basins, and for the region as a whole.

The following sources were consulted in preparing this inventory. The reader is referred to these sources for more detailed information on individual techniques.

- The Management Practices Inventory of the Hampton Roads Water Quality Management Plan, Hampton Roads Water Quality Agency, 1979.

- Best Management Practices Handbook, State Water Control Board, 1979.

- Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs, Metropolitan Washington Council of Governments, 1987.

- Virginia Beach Stormwater Management Plan, Camp, Dresser and McKee, 1987.

- Draft Virginia Nonpoint Source Pollution Management Program, Virginia Department of Conservation and Historic Resources, 1989.

NON-STRUCTURAL CONTROLS

Land Use Controls

Land use control has the potential to be the most effective means for managing NPS pollution in areas which are expected to experience development. By limiting the use and development density of land, the types and quantities of NPS pollutants are controlled at the source, thus minimizing the need for downstream control measures. The Chesapeake Bay Preservation Act, which was enacted in 1988, provides Virginia localities with the authority to incorporate water quality protection measures into their comprehensive plans, and zoning and subdivision ordinances. A locality might incorporate the following strategies into their land use control programs to minimize NPS pollution.

Traditional Zoning

In general, a traditional zoning ordinance delineates zoning districts, lists permitted and conditional uses in each district, and establishes basic development requirements for each district (i.e., minimum setbacks, side yards, lot size and building height). NPS pollution in environmentally sensitive areas might be minimized by rezoning, downzoning or adding regulations to existing zoning districts. These measures could preclude certain uses which generate particularly high levels of NPS pollution, or could decrease the amount of impervious surface area by increasing minimum lot size and/or decreasing maximum lot coverage.

In many cases, traditional zoning may be too inflexible to adequately achieve NPS control objectives. The remainder of this section describes innovative techniques which might be incorporated into a community's land use and development controls to achieve NPS management objectives.

Overlay Zoning

Overlay zoning offers an alternative to the sometimes static nature of traditional zoning. Overlay zones are not intended to replace or change existing zoning requirements. Instead, they are superimposed on existing zoning districts to provide additional land use regulations. In the context of NPS pollution control, overlay zoning might be used in environmentally sensitive areas to impose stormwater runoff performance standards, to require stormwater management BMPs, to preserve trees and create vegetated buffers, or to prohibit the storage or use of hazardous materials.

Open Space Requirements

As a condition for approval of a final subdivision map, localities often require developers to reserve open space for acquisition by that locality. Although the common use of this strategy is to preserve open space for recreation, a locality may want to consider amending its subdivision ordinance to allow open space reservation for the purpose of buffering environmentally sensitive areas from sources of NPS pollution. Another technique, conditional zoning, might be used by a locality to encourage a developer to proffer open space for the same reason.

Performance Standards

In contrast to the conventional use and density restrictions imposed under traditional zoning, the intensity of development is sometimes controlled by the application of environmental performance standards. Through the use of such standards, selected uses or mixes of uses are allowed within a zoning district only if they meet certain "performance" criteria. In the context of stormwater management, a performance standard might require that the quantity and quality of runoff from a site during certain storm events not exceed pre-development levels. Standards might also require that the "first flush" of rainfall be retained on-site.

Transfer of Development Rights

Through the transfer of development rights (TDR), a property owner in designated areas, known as "sending zones", may transfer (sell) the development rights granted to him under the zoning ordinance to a property owner in a designated "receiving zone" where conditions for development are more appropriate. A TDR program could be used to shift development densities and associated stormwater runoff problems away from sensitive environmental areas. At present, the use of TDR is not permitted under state enabling legislation.

Cluster Zoning

Cluster zoning is a technique by which permitted development density is concentrated on only a portion of a site. This allows the remainder of the site to be retained in an undeveloped, natural state. Clustering can be encouraged by offering density bonuses as an incentive. Cluster zoning can provide NPS pollution control by reducing the total amount of impervious area and directing development away from environmentally sensitive portions of the site.

Planned Unit Development

Planned Unit Development (PUD) is a technique by which subdivision and zoning regulations apply to an entire project area rather than to individual lots. This allows site designs which cluster development and maximize areas available for the development of public facilities and the preservation of open space. PUD differs from cluster zoning in that a PUD is larger in scale and is usually a mixed use development. Like cluster zoning, PUD can be used to concentrate development in appropriate areas and to protect environmentally sensitive areas.

Vegetative Controls

Vegetative controls rely on various forms and species of plants to remove NPS pollutants. By themselves, vegetative controls are not usually sufficient enough to completely control increased runoff and associated NPS pollutant loads from a development site. Their principal usefulness lies in their ability to improve the performance of other BMPs. Another advantage of vegetative controls is that they can be retrofitted into already established developments. The following is a description of some commonly used vegetative controls.

Grassed Swales

Grassed swales are typically used in low density developments as an alternative to curb and gutter drainage systems. The removal of pollutants is achieved by the filtering action of the grass, deposition in low velocity areas and infiltration into the subsoil. Grassed swales have a limited ability to accommodate major runoff events and will be effective in removing pollutants during small storms only. Therefore, they usually lead to storm drains and downstream BMPs to achieve maximum stormwater quantity and quality control. The performance of grassed swales can be improved with the installation of check dams which are used to temporarily pond runoff.

Filter Strips

Filter strips, also known as buffer zones, are similar to grassed swales except that they are normally wider, are usually forested, and are designed to receive overland sheet flow. Filter strips are most often used to protect environmentally sensitive areas, but can also be used to protect surface infiltration devices. They also provide secondary benefits by providing wildlife habitat, aesthetics and noise screening. To be effective, filter strips should be at least 20 feet in width, should not be used on slopes greater than 15%, and should accept evenly distributed sheet flow.

Urban Forestry

Urban forestry is a practice which involves reducing the amount of runoff from a site by preserving existing vegetation during construction or by planting trees, shrubs and ground cover after a site has been cleared or fully developed. Sites landscaped with such vegetation have been found to generate considerably less runoff than sites planted with grass. Urban forestry can reduce the export of pollutants from a site by plant uptake and storage, by enhancing soil infiltration, by reducing the volume of runoff, and by preventing soil erosion. Secondary benefits provided by urban forestry include noise absorption, shade, visual screening, wind protection and wildlife habitat.

Other Non-Structural Controls

Street Sweeping

Frequent and efficient street sweeping can remove street contaminants before they are washed off into receiving waters during storm events. Under ideal operating procedures and conditions, street sweeping can remove up to 50% of the pollutants accumulated on urban streets.[19] Street sweeping is most effective on paved streets with curbs and gutters, but may be beneficial on all paved areas including parking lots, alleyways, driveways, and so forth. The most common methods of street sweeping are mechanical (broom) and vacuum sweepers. Vacuum sweepers are considered to be the most effective for NPS pollution control.

Education, Training and Community Involvement Programs

Many possibilities exist at the local and regional levels for educating local government staff, developers, business owners and residents about NPS control. At the local government level, training programs are often necessary to keep staff informed about rapidly evolving local, state and federal initiatives in NPS management.

Education and training programs could also be implemented to make local residents and the business community aware of how their activities contribute to NPS pollution, and what their role is in solving the problem. Such programs might address any number of NPS related issues discussed elsewhere in this chapter. These include E&S control during construction, the installation of structural BMPs in new development, solid and hazardous waste disposal and/or recycling, proper fertilizer and pesticide management, proper vehicle maintenance, landscaping to control runoff, and proper outside material storage. Methods for distributing this information might include seminars, brochures and flyers, public service announcements, local cable access programing, traveling exhibits, and speaker outreach programs.

Another strategy is to actively involve private citizens in water quality management efforts. The Alliance for the Chesapeake Bay, the Back Bay Restoration Foundation and the Albemarle-Pamlico Estuarine Study have successfully used volunteers in water quality sampling and habitat restoration projects. Innovative citizen involvement and education programs aimed at preventing the disposal of toxic wastes in storm drains have been successfully implemented by Anne Arundel County, Maryland and the State of Washington. In these programs, volunteer organizations or, in Washington state, violators of toxic waste disposal laws stencil a message on storm drains advising against the dumping of waste. In both cases, stenciling kits are provided free of charge to interested organizations by the responsible agencies.

Urban Fertilizer and Pesticide Application and Disposal Control

Improper use and disposal of fertilizers and pesticides in urban areas can have significant adverse effects on water quality. Improper use of fertilizers will lead to excessive nutrient loads in runoff which may stimulate algal growth and eutrophication in receiving waters. Improper use of pesticides may result in the introduction of acutely toxic chemicals into stormwater runoff which could have severe effects on water-based food chains. Programs which educate residents and businesses in the proper use of fertilizers and pesticides could be implemented at the local level. Fertilizer management programs would focus on such issues as over-application; timing of application; erosion control measures in fertilized areas; and, alternatives to fertilization. Pesticide management programs would address proper dosages; selection of appropriate products; proximity of application to humans, animals and environmentally sensitive areas; timing of application; proper storage and disposal; and alternatives to pesticides..

Routine Maintenance and Inspection Program for Structural Controls

In some cases, the responsibility of inspecting and maintaining structural stormwater management controls is left to private land owners or homeowners associations. This arrangement may lead to the neglect of key inspection and maintenance duties. Local governments could implement annual or semi-annual inspection programs to check the operational effectiveness and integrity of structural controls. Where there are deficiencies, those responsible would be encouraged or possibly required to take remedial action. The authority to require maintenance and repair of privately owned BMPs appears to be granted by Section 10-320 of the Chesapeake Bay Preservation Act which authorizes localities to exercise their police and zoning powers to protect the quality of state waters. Public maintenance may be necessary for major control structures which serve larger areas containing a mix of new and existing development.

Improved Sanitary Sewer System Inspection and Maintenance

Leaks, overflows and illegal connections from sanitary sewer systems can be significant NPS pollution problems. The EPA's proposed stormwater permitting regulations would require localities with populations greater than 100,000 to conduct screening analyses for all illicit discharges to storm sewer systems, including those from sanitary sewers. The regulations would also require the regulated localities to develop local control and prevention programs. To meet these regulations, local governments might find it useful to coordinate their efforts with an inspection program recently implemented by the Hampton Roads Sanitation District (HRSD). The HRSD created and approved funding for a Systems Reliability Division which will inspect the District's pump stations, mains and 373 miles of lines for deficiencies. This program augments the existing HRSD-local government program to correct infiltration and inflow problems in the region's sanitary sewer system.

Septic System Inspection Program

In areas with poorly drained soils and/or high water tables, effluent seepage from on-site septic systems into streams or groundwater may cause severe water quality problems.[20] The region's localities, through their capital improvements programs, have implemented ongoing programs to provide public sewer service in areas where on-site septic systems are inappropriate. In areas where public sewer service is not provided, the State Health Department (SHD) conducts surveys of septic systems on a case-by-case basis. These surveys are generally conducted in response to overt failures, to evaluate the need for public systems or as a service to homeowners when a home is sold. A more systematic and comprehensive program may be needed to adequately address the problem of septic system failure. The 1989 Virginia General Assembly recognized this need when it passed a resolution encouraging localities to promote the proper operation and maintenance of on-site sewage disposal systems through the establishment of on-site sewage management districts.

Sanitary Shoreline Survey Program

The Division of Shellfish Sanitation (DSS) of the SHD conducts shoreline surveys to identify and evaluate actual and potential sources of pollution that may affect shellfish growing areas. These surveys are conducted in conjunction with bacteriological water sampling. Attempts are made during shoreline surveys to identify both point and nonpoint sources of pollutants. The surveys, which are reviewed annually and completely reevaluated every three years, are conducted only in shellfish growing areas and are used to classify growing areas as to their sanitary quality. Local governments might consider adopting the DSS survey methodology, especially as it pertains to nonpoint sources, and conducting similar surveys in areas not designated as shellfish growing areas. Local governments might also coordinate their efforts with the DSS to increase the frequency and effectiveness of NPS surveys in designated shellfish growing areas.

Proper Location and Containment of Dredge Spoils

Improper NPS management at dredge spoil sites may result in the reintroduction of sediment, and pollutants contained in sediment, to receiving waters. To avoid this situation, dredge spoil sites should be located and designed to minimize runoff problems. Sites should be located at appropriate distances from shorelines and marsh areas. They should also be confined by vegetated earthen berms which are built well above the spring tide height. Most disposal sites are equipped with some type of sluicing device which regulates dewatering of the spoil and helps to control the quality of the effluent. If, however, discharge from a bermed disposal site with a sluicing device results in water quality problems, it may be necessary to install nonmechanized or mechanized filter systems. Nonmechanized systems include pervious dikes, sandfill weirs, straw bales and granular media cartridges. Mechanized systems, which would only be used at large disposal sites, include pressure filters, vacuum filters, microscreens, and horizontal and vertical belt filter presses.

As an alternative to stockpiling, consideration should be given to using dredge spoils to restore fringe marsh, create buffer islands, provide fill for upland construction, fill mine pits or caverns, and regrade eroded bluffs.

Proper Location and Containment of Outside Material Storage

The outside storage of materials at commercial and industrial sites is often a source of NPS pollution. Facilities that store pesticides, fertilizers, deicing compounds and construction materials are of particular concern. To minimize contaminated runoff from outside storage sites, several siting and design guidelines should be followed. Storage sites should be protected from excessive heat, cold and moisture. They should also be located away from flood prone areas, aquifer recharge areas and established drainage features. Materials should be stored on impermeable surfaces and trenches or barriers should be built around sites to trap runoff and/or spillage. Finally, manufacturer's storage recommendations should be followed in order to maintain the integrity of the material.

Reduction of Traffic Generated Pollutants

In addition to air pollutants, motor vehicle traffic generates a variety of land pollutants and is responsible for a significant portion of the NPS problem in urban areas. NPS pollutants generated by motor vehicles include airborne pollutants which reach the ground through natural settling or precipitation; asbestos and metals from brake wear; rubber particles from tires; leakage of fuel and other fluids; metals from corrosion of vehicles; and, asphalt material from both tire abrasion and corrosion from gasoline leaks. Two strategies for reducing the impacts of traffic generated pollutants, street cleaning and vegetative buffers, are discussed elsewhere in this chapter. Proper vehicle maintenance by individuals and fleet operators is also an important means of minimizing pollution generated by motor vehicles. Maintenance practices which reduce the amount of pollutants generated by motor vehicles include repairing fluid and fuel leaks; adhering to recommended tuneup schedules; balancing tires and aligning wheels; maintaining good brake performance; avoiding the "topping off" of gas tanks; and disposing of used oil properly. Encouraging individuals to better maintain their motor vehicles can be accomplished through public education programs or by including procedures in the State motor vehicle inspection program which ensure that motor vehicles are not generating excessive amounts of pollutants. Local governments can play a direct role in reducing motor vehicle generated pollutants by ensuring that their own fleets of vehicles are properly maintained.

Another strategy for reducing the amount of pollution generated by motor vehicles is to implement local or regional programs which reduce the total amount of vehicle miles traveled in an urban area. This can be accomplished by improving and marketing public transportation, encouraging car pooling, and promoting alternative modes of transportation such as bicycling and walking.

Control of Highway Deicing Chemicals

Highway deicing chemicals, which are usually a mix of sodium chloride and calcium chloride, play an important role in preventing snow and ice accumulation on streets. Such chemicals, however, may contribute directly and indirectly to NPS pollutant loads. Direct NPS impacts may result from street or storage site runoff. Indirect impacts may result from corrosion of vehicles and roadways, and deterioration of roadside soils and plants. Measures to mitigate the effects of deicing chemicals include the planting of salt tolerant vegetation along roadsides; proper storage of materials (see above discussion of outside material storage); street cleaning after application; and development of appropriate application priorities, rates and techniques to minimize the amounts of chemicals used.

STRUCTURAL CONTROLS

Dry Detention Basins

Dry detention basins are designed to store stormwater runoff during and shortly after a storm and to drain completely at allowable release rates. Dry basins can provide limited water quality benefits through the settling of suspended pollutants. Although dry basins serve primarily to reduce suspended pollutants, partial removal of soluble pollutants can be achieved by incorporating artificial wetlands into the lower areas of a basin. Because only limited removal of soluble pollutants is possible within dry basins, wet basins are generally preferred in the development of stormwater management programs.

Extended Detention

Most pollutants tend to be associated with small sediment particles. Because smaller particles remain suspended longer than larger particles, relatively long basin detention times (12 to 48 hours) are required for optimal pollutant removal. It is recommended that dry basins be designed for a dual purpose. The top portion of the basin would have a relatively short detention time and would serve to rapidly evacuate runoff from large storm events. The bottom portion of the basin would be regularly inundated and, with a longer detention time, would provide water quality control.

Parking Lot Storage

Detention of stormwater on paved parking areas is generally used to control runoff volumes and has only limited application as a BMP. Because extended detention volumes and times would interfere with the intended use of a parking lot, only minimal NPS control benefits can be realized. The effectiveness of parking lot storage can be improved by directing runoff to subsurface infiltration or retention devices.

Wet Detention Basins

A wet detention basin generally consists of both a permanent pool with additional storage capacity above the pool level to accommodate runoff from major storm events. Whereas dry detention basins are effective in removing suspended pollutants only, wet basins also utilize natural chemical and biological processes within the permanent pool to achieve removal of dissolved pollutants. These processes include uptake of nutrients by algae and submerged aquatic vegetation, and adsorption of nutrients and heavy metals onto bottom sediments. In addition to having significant pollutant removal potential, wet detention basins may also provide recreational and aesthetic benefits. For these reasons, wet basins are generally preferred over dry basins in controlling NPS pollution.

The design of every wet and dry basin should include a landscape plan. The type of vegetation used to stabilize a basin will play a significant role in pollutant removal performance, appearance and habitat value. Also, it is important to implement a maintenance plan to ensure that a basin continues to function as intended and retains its aesthetic qualities.

Extended Detention Wet Basins

Devices can be installed in wet detention basins to delay drainage from wet detention basins and provide additional removal of NPS pollutants. These devices, which are normally attached to low flow orifices or risers, impede drainage during minor runoff events, but allow maximum drainage during major events. Such devices are an attractive option for retrofitting existing wet basins in previously developed areas.

Infiltration Devices

Infiltration devices allow runoff to filter through the soil layer where a number of physical, chemical and biological pollutant removal processes can occur. Such devices are particularly advantageous in that they preserve the natural groundwater recharge capabilities of a site. Infiltration devices should not be relied on to remove large quantities of sediments since basins can become easily clogged. Rather, they should be used in conjunction with other BMPs that remove sediment before it enters the device. Infiltration devices are only practical where soils are permeable and where the water table or bedrock are located well below the bottom of the device.

Trenches

Infiltration trenches are shallow (3-8 feet deep) and are filled with stone to create an underground reservoir. Runoff can either drain from the reservoir into the underlying subsoil (exfiltration) or be collected by underdrains and directed to an outflow. Trench dimensions will depend on the volume of runoff to be controlled and the degree to which runoff is disposed of through exfiltration. In general, however, infiltration trenches can only accommodate limited quantities of runoff and are typically used on sites of less than 5 acres in size. Trenches can either be located on or below the surface. Surface trenches, which are most appropriate in residential areas, would normally accept sheet runoff from adjacent areas that has been filtered through a grass swale. Underground trenches, which are more suited to commercial and industrial areas, receive more concentrated runoff (from pipes and storm drains) and usually require special inlets that trap coarse sediment and oil/grease. The first method provides superior pollutant removal benefits.

Dry Wells, a variation of the infiltration trench concept, are designed exclusively to receive rooftop runoff. Roof leaders are extended to a trench located a minimum of ten feet from the building foundation.

Basins

Unlike trenches, infiltration basins can be designed to accommodate peak discharges of large design storms and can serve drainage areas of up to 50 acres. Infiltration basins are similar in design to dry detention basins. The difference is that dry detention basins are designed to promote delayed drainage from the basin whereas infiltration basins are designed to promote exfiltration through the subsoil underlying the basin. Infiltration basins should be vegetated and often include devices which prevent coarse sediment from entering the basin as well as emergency spillways for extreme storm events. During dry weather an infiltration basin might be used for recreation.

Rooftop Detention and Disposal

In densely developed areas, rooftops represent a significant amount of impervious surface which generates large quantities of stormwater runoff. Rooftops can be designed to detain water and release it at a gradual rate. By doing this, the first flush of pollutants can be minimized and roof runoff can be directed to infiltration devices, such as dry wells, which provide NPS pollutant removal. Runoff could also be directed to underground cisterns where it can be gradually released to the storm sewer system, or pumped for uses that do not require treated water. Roof detention can be achieved by installing devices around the inlets of downspouts which allow normal drainage during minor storm events and ponding and gradual drainage during major events. Consideration must be given to the structural integrity of a roof when designing a rooftop detention system.

Cistern Storage

Underground cisterns can be used to collect the first flush of stormwater runoff thus minimizing downstream water quality impacts. Water captured in a cistern can either be slowly released or used for on-site purposes such as lawn watering or fire suppression. A cistern might be used by one or shared by several sites.

Pervious Pavement

Road pavement is normally impervious and generates considerable quantities of runoff. The traffic-generated pollutants contained in this runoff can have severe water quality impacts. Pervious pavement serves to detain and minimize the effects of the first flush of pollutants. It also provides for the removal pollutants through infiltration and bacterial action. Despite its pollutant removal potential, pervious pavement has a number of shortcomings which limit its applicability. Its use therefore is generally confined to low-volume traffic areas such as parking areas, residential streets, recreation areas and so forth.

Concrete Grid and Modular Pavement

This type of pervious pavement consists of a grid made of concrete, clay bricks or granite sets. The void areas of the grid are filled with a pervious material such as sod, gravel or sand.

Porous Asphalt

Porous asphalt consists of a graded aggregate cemented by asphalt cement, with sufficient interconnected voids to provide a high rate of permeability.

Stormwater Conveyance System Design

Several pollution control devices can be incorporated into the design of new or existing storm sewer systems. These include storage facilities, flow regulators and treatment facilities.

A variety of in-line, off-line or stream channel storage facilities can serve to reduce downstream flow peaks and provide limited particulate removal through flow detention. In-line storage is achieved by restricting flow within a conduit with dams, gates or weirs. Off-line storage is achieved by routing overflows into separate holding devices such as reservoirs, lagoons, underground silos, underwater bags, void space storage, deep tunnels, and mine labyrinths. Stream channel storage is accomplished by relocating channels, creating side channels, or using in-channel dams or weirs.

Flow regulators can be incorporated into a storm sewer line to control the direction, volume or velocity of stormwater flows. They can reduce the discharge of NPS pollutants within storm sewer systems by diverting the first flush and/or the overflow of storm events into stormwater control facilities. Flow regulators can either be conventional or fluidic. Conventional regulators are either manually or electronically controlled while fluidic regulators operate in response to changes in water level or flow characteristics.

Several physical and chemical treatment techniques exist for removing contaminants from stormwater collected within a conveyance system. The physical techniques are generally used for removing solids. They include sedimentation tanks, filtration through a porous material, screening, swirl regulator/concentrators and water quality inlets. Water quality inlets are also used for oil and grease removal. Chemical treatment techniques include the removal of solids through flocculation and the application of disinfection agents to destroy pathogenic micro-organisms.

LOCAL AND REGIONAL INSTITUTIONAL STRATEGIES

Compliance with Chesapeake Bay Preservation Act Criteria

The Chesapeake Bay Preservation Act (CBPA) authorizes all Virginia localities to exercise their land use powers to protect water quality. It also requires Tidewater localities to designate Chesapeake Bay Preservation Areas which, if improperly developed, may result in water quality degradation from NPS pollution. Tidewater localities are also required to incorporate water quality protection measures into any land use regulations that apply to development within Preservation Areas. Draft criteria for defining and protecting Preservation Areas were made available for public comment in April, 1989 and are contained in Appendix B. The Act mandates that the Board adopt these criteria by July 1, 1989.

Compliance with the CBPA criteria will involve the development of NPS control strategies to protect environmentally critical areas. Implementation of these strategies will help meet the requirements and recommendations of other NPS control initiatives including the EPA stormwater permitting programs and the Virginia Nonpoint Source Management Program. Conversely, compliance with other state and federal NPS management initiatives will lead to the development of strategies that meet the CBPA criteria.

Stormwater Management Ordinances

The overlapping requirements of the various state and federal NPS management initiatives point to the need for local stormwater management programs which integrate these requirements in a coordinative, non-duplicative manner. The 1989 Virginia General Assembly passed legislation which enables a local government to establish, by ordinance, such a program. Under this legislation, a local stormwater management program would require submission and approval by the local government of a stormwater management plan prior to any non-exempt development activity. This plan would have to meet criteria contained in a local stormwater management ordinance. Regulations are currently being developed to guide the development of local programs.

In 1988, the City of Virginia Beach adopted a stormwater management ordinance which requires a developer to submit a Stormwater Management Plan prior to development. This plan is required to describe existing hydrologic conditions, proposed site alterations, predicted impacts of proposed development, the proposed drainage system, and any BMPs to be implemented. The Plan must also demonstrate that the proposed development will meet a number of performance standards described in the ordinance.

Revision of Subdivision and Site Plan Review Procedures

As mentioned above, the Chesapeake Bay Preservation Act authorizes Virginia localities to exercise their land use powers to protect water quality. It also requires all Tidewater localities to incorporate water quality protection measures that meet State criteria into their land regulations. Under the draft criteria, Tidewater localities would have to revise their subdivision ordinances to restrict platting in and provide buffers around environmentally sensitive areas. In the absence of a stormwater management ordinance, a locality would have to revise its zoning or site plan review ordinances to require additional site plan review procedures in environmentally sensitive areas. These procedures would require a developer to assess post-development water quality and peak flow impacts from a proposed development, and design BMPs which meet predetermined runoff performance standards.

Improved Implementation of Erosion and Sediment Control Ordinances

The Virginia Erosion and Sediment Control Law (ESCL) was passed in 1973 to minimize soil erosion and runoff during construction activities. The law requires that local erosion and sediment (E&S) control programs be developed and implemented by local governments or the Local Soil and Water Conservation Districts. Under the ESCL, any party engaging in a "land disturbing activity" must submit and receive approval for an erosion and sediment control plan before work can proceed. The State's primary role in the administration of local programs is the establishment of E&S control guidelines and standards which are published in the Virginia Erosion and Sediment Control Handbook. Initially, the ESCL and the E&S Control Handbook only addressed erosion and flooding concerns related to construction site runoff and did not specifically address water quality. This was changed in 1988 when the ESCL was amended to require that local programs be developed to "prevent the unreasonable degradation of properties, stream channels, waters and other natural resources ...".[21]

In order to better control the runoff of sediments and other NPS pollutants from construction sites, a locality may wish to strengthen its E&S control program by exceeding the minimum guidelines and standards established by the State. It may also consider increasing its enforcement activities to ensure that approved E&S control plans are being followed, and that violations are quickly corrected. A locality may also want to conduct educational programs providing information on program requirements to developers, and encourage local E&S control officials to complete the State E&S control certification program.

Watershed Management Plans

Urban watersheds vary significantly with respect to size, topography, soil conditions, stormwater conveyance and treatment systems, the rate of urbanization, and the type and intensity of land use. Consequently, the quantity and quality of stormwater discharges within each watershed will differ, as will stormwater management needs. Furthermore, many NPS control strategies focus on NPS pollutants generated by shoreline uses or are designed to protect environmentally sensitive areas that are directly associated with waterways. In reality, many NPS pollutants are generated by activities located at some distance from the shoreline in the upstream portions of a watershed. It is for these reasons that consideration should be given to the development and implementation of watershed-specific stormwater management plans. These plans might be developed by individual localities, or through interlocal cooperative efforts in instances where watershed and political boundaries do not coincide. Watershed management plans would consist of an identification and assessment of NPS problems, a set of goals and objectives, and a management plan consisting of implementation strategies required to meet the plans's goals and objectives. To be effective, the components of watershed management plans must be integrated into existing policies and regulations governing development.

The legislation passed by the 1989 General Assembly allowing localities to adopt stormwater management ordinances requires the preparation of watershed management studies before a locality adopts stormwater management regulations that are more stringent than those necessary to ensure compliance with the State's minimum criteria.

In developing the proposed stormwater permitting regulations, the EPA recognized that watershed planning is the preferred approach in stormwater management. Due to anticipated administrative burdens, however, the EPA proposes to use jurisdictional rather than watershed boundaries in defining and regulating municipal separate storm sewer systems. The EPA will encourage the incorporation of watershed planning concepts and controls into the application requirements and ultimately into the permit conditions.

Regional Implementation of Stormwater Control Strategies

A possibility for improving the effectiveness of local stormwater management activities is the establishment of a regional, cooperative stormwater management program. This program might be implemented by one or more existing regional entities (HRSD, SPSA, HRWQA or SVPDC). The benefits of such a program would include assistance to localities in complying with the EPA stormwater permitting regulations, including a regional approach to meeting the sampling and monitoring requirements; providing a regional forum through which information can be exchanged on the development and implementation of stormwater control strategies; facilitating intergovernmental efforts to promote state legislative actions needed for better stormwater management; and, coordinating the development of watershed management plans where a watershed is shared by more than one jurisdiction.

Stormwater Utilities

To achieve more efficient and effective management of stormwater quantity and quality, a locality or a regional entity may decide to create a stormwater utility. This utility would be responsible for comprehensive stormwater management planning; financing; constructing and maintaining drainage conveyances and structural BMPs; and implementing certain nonstructural BMPs. Establishing a stormwater utility may be more difficult than establishing other public utilities. Such issues as defining service boundaries, determining the non-exempt customers of the utility, and developing a rate structure and billing system may present problems. It should be noted that new state enabling legislation will be required before local governments can implement this approach.

Local and Regional Solid Waste Management Plans

The traditional benefits of solid waste management include nuisance abatement, reduction of fire hazards, improved aesthetics, and control of insects and rodents. NPS pollution control is often achieved, but as a secondary benefit. Solid waste, if washed away in runoff, can contribute to NPS pollution. This can occur as a result of littering; improper collection, transport or unloading of waste; or poor landfill management practices. Strategies commonly included in solid waste management plans also serve to reduce NPS pollution by reducing the amount of waste that may reach waterways directly in runoff. These include anti-littering, recycling, composting, incineration and waste to energy programs. Other strategies minimize pollutants in runoff by encouraging the proper containment of waste during handling. Finally, certain structural BMPs are required at landfills to control runoff contaminated by leachate. These include a wide variety of landfill management techniques to prevent infiltration; control erosion; collect, transfer, store and treat runoff; and protect the site from floods. Such techniques have been successfully implemented at the Southeastern Public Service Authority of Virginia's (SPSA) regional landfill in Suffolk.

SPSA has recently begun the preparation of a regional solid waste plan for Southeastern Virginia. This plan will address a number of solid waste management issues that relate to NPS pollution control. The SPSA has also initiated a pilot recycling program which serves selected neighborhoods throughout the region. If successful, this program will be extended to the rest of the region.

Programs to Control Illicit Discharges

The EPA has determined that abatement of illicit discharges to urban storm sewer systems presents opportunities for dramatic improvements in the quality of urban stormwater discharges.[22] Illicit discharges include those resulting from defective plumbing, from illegal connections with sanitary sewers or commercial and industrial operations, and from the improper management of used oil and other toxic materials. The EPA's proposed stormwater permitting regulations would require localities with populations greater than 100,000 to conduct screening analyses to detect illicit discharges and to develop local control and prevention programs. The local programs would be required to address local regulatory measures for preventing illicit discharges; ongoing sampling or other detection procedures; procedures for preventing and responding to spills; public education programs; and controls to limit infiltration from sanitary sewers. Although not presently required by the EPA to do so, localities with populations less than 100,000 might consider developing programs to control illicit discharges which meet the EPA requirements as part of their overall stormwater management strategies.

Tax Incentives

Localities may want to consider lowering the property tax assessment on land used for the purpose of controlling NPS pollution. This procedure is commonly known as use-value taxation. Such land might include areas where BMPs are installed or areas where open space has been preserved for NPS pollution control. The State Code allows the use-value taxation of open space preserved for the protection of natural resources as long as certain conditions are met. The use-value taxation of land devoted to structural BMPs would require new enabling legislation, however.

Incorporation of Control Strategies into Public Projects

It is imperative that local governments demonstrate a commitment to NPS control by incorporating structural and non- structural BMPs into the development and maintenance of public facilities. This would not only provide water quality benefits, but would allow local governments to evaluate the effectiveness of techniques that they may want to incorporate into local land use and development regulations. Use of BMPs by local governments could also serve as a way of demonstrating proper installation and maintenance procedures to private developers and landowners.

EVALUATION OF NONPOINT SOURCE CONTROL TECHNIQUES APPLICABLE TO MUNICIPAL STORMWATER SYSTEMS

The selection of NPS control techniques to be incorporated into a stormwater management program will be guided by a wide range of considerations. The primary consideration will most likely be cost-effectiveness, or the economic efficiency of a technique in achieving NPS pollutant removal. However, for many techniques, the cost and pollutant removal efficiency data necessary to conduct a reliable cost-effectiveness analysis do not exist. In such cases, knowledge of local conditions and circumstances may have to substitute for a detailed economic analysis. There are other factors, besides cost-effectiveness, that need to be taken into account in selecting NPS control techniques. These include the need to control runoff rate and volume; necessary legislative authority; delegation of maintenance responsibilities; physical constraints such as topography, land availability, soil permeability or water table depth; and, social and aesthetic concerns.

Table 2 provides a general evaluation of the structural and non-structural BMPs identified in this study. The evaluation procedure used in Table 2 was developed by the Virginia Soil and Water Conservation Commission (presently the Division of Soil and Water Conservation) for the State Urban Best Management Practices Handbook. This procedure rates each BMP with respect to its ability to control the quantity and quality of stormwater; its applicability to different types, densities and sizes of development; and to other considerations which will influence the selection process. It does not address the economic costs associated with each BMP. As mentioned above, information is not available to conduct a thorough cost-effectiveness comparison of the alternative techniques. Table 2 provides a broad overall comparison of techniques only. Before making a final decision to incorporate specific BMPs into a NPS control program, more detailed analysis should be undertaken.

A formal evaluation was not conducted for the institutional strategies identified in this report. This is because, for the most part, these strategies represent general management approaches which may be structured and implemented differently depending upon locality-specific NPS management objectives. In addition, two of the strategies, compliance with the CBPA criteria and a program to control illicit discharges, will be mandatory under state and federal programs. Consequently, there would be little use in including these strategies in a comparative evaluation since most local jurisdictions will be required to incorporate them into their stormwater management programs.

TABLE 2
EVALUATION OF NON-STRUCTURAL AND STRUCTURAL BEST MANAGEMENT PRACTICES

Note: Superscript numbers refer to explanatory notes on following page

Letter Key:
- H = High
- M = Moderate
- L = Low
- V = Variable
- NA = Not Applicable

Best Management Practices	Types of Control			Applicability						Other Considerations					
	Control of Particulate Pollutants	Control of Soluble Pollutants	Control of Runoff Rate and Volume	New Development	Existing Development	Low-Moderate Density Development	High Density Development	Site Specific Applications	Areawide Applications	Municipal Responsibility	Property Owner Responsibility	Aesthetic/Environmental Improvement	Groundwater Pollution	Maintenance Requirements	Land Requirements
Non-Structural															
Land Use Controls	H	H	V	H	L	M	H	H	H	H	NA	H	L	L	H
Vegetative Controls	M	M	L	H	L	H	L	H	M	V[11]	H	H	M	M	M
Street Sweeping	M	L	NA	M	H	M	H	M[2]	H	H	H[2]	H	L	H[3]	NA
Education, Training and community Involvement Program	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]	V[4]
Urban Fertilizer and Pesticide Application and Disposal Control	L	H	NA	H	H	H	H	H	H[5]	M[6]	H	L	L	NA	NA
Route Mainenance and Inspection Program for Structural Controls	V[7]	V[7]	V[7]	V[7]	M	M	H	H	H	H	H	V[7]	L	NA	NA
Improved Sanitary Sewer System Inspection and Maintenance	L	H	NA	L	H	H	H	L	H	H	L	L	L	NA	NA
Septic System Inspection Program	L	H	NA	L	H[8]	M[8]	H[8]	H	H[8]	M	L	L	L	NA	NA
Sanitary Shoreline Survey	L	H	NA	L	H	H	H	L	H	M	L	L	L	NA	NA

TABLE 2 (Continued)
EVALUATION OF NON-STRUCTURAL AND STRUCTURAL BEST MANAGEMENT PRACTICES

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	Types of Control			Applicability						Other Considerations					
Best Management Practices	Control of Particulate Pollutants	Control of Soluble Pollutants	Control of Runoff Rate and Volume	New Development	Existing Development	Low-Moderate Density Development	High Density Development	Site Specific Applications	Areawide Applications	Municipal Responsibility	Property Owner Responsibility	Aesthetic/Environmental Improvement	Groundwater Pollution	Maintenance Requirements	Land Requirements
Proper Location and Containment of Dredge Spoils	H	M	NA	NA	NA	NA	NA	H	L	M[5]	H	L	L	M	H
Proper Location and Containment of Outside Material Storage	H	H	NA	NA	NA	NA	NA	H	L	M[5]	H	L	L	M	H
Reduction of Traffic Generated Pollutants	M	M	NA	M	H	M	H	NA	H	H[6]	M	M	L	H[9]	NA
Control of Highway Deicing Chemicals	H	H	NA	M	H	H	H	L	H	H[10]	L	L	L	M[3]	NA
Structural															
Extended Detention Dry Basins	H	L	H	H	L	H	L	H	H	V[11]	H	M	L	M	H
Parking Lot Storage	L	L	H	H	L	M	M	H	NA	L	H	NA	NA	H	NA
Wet Detention Basins[12]	H	M	H	H	L	H	L	H	H	V[11]	H	H	L	M	H
Extended Detention Wet Basins[12]	H	H	H	H	L	H	L	H	H	V[11]	H	H	M	H	H

TABLE 2 (Continued)
EVALUATION OF NON-STRUCTURAL AND STRUCTURAL BEST MANAGEMENT PRACTICES

Note: Superscript numbers refer to explanatory notes on following page

Letter Key:
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Best Management Practices	Types of Control			Applicability						Other Considerations					
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Infiltration Trenches	M	M	M	H	V[1]	H	L	H	L	L	H	L	M	H	L
Infiltration Basins	M	H	H	H	L	H	H	H	L	L	H	M	M	H	M
Rooftop Dention and Disposal	M	L	H	H	L	M	H	H	NA	M[12]	H	NA	NA	M	NA
Cistern Storage	M	L	H	H	M	M	H	H	L	L	H	NA	NA	M	L
Pervious Pavement	M	M	H	H	L	M	H	H	M	V[11]	H	L	M	H	L
Stormwater Conveyance System Design	H	L	H	H	M	H	H	M	H	H[11]	H[11]	NA	NA	H	V1

Source: Adapted from: State Best Management Practices Handbook: Urban, SWCB, 1979.

TABLE 2 (Continued)

EVALUATION OF NON-STRUCTURAL AND STRUCTURAL BEST MANAGMENT PRACTICES

EXPLANATORY NOTES

1. Depends on type of control and individual site characteristics.
2. Parking lots and other large paved areas.
3. Vehicle and equipment maintenance.
4. Depends on nature of individual programs.
5. Areawide control policy or regulation.
6. Policy making and public information/education.
7. Depends on BMP being inspected or maintained.
8. Where sanitary sewers do not exist.
9. Air pollution controls may require increased vehicle maintenance.
10. Primary responsibility for State roads lies with the Virginia Department of Highways and Transportation.
11. Dependent upon location and ownership.
12. Assumes well designed detention basin with appropriate inflow/volume ratio.

GENERAL EXPLANATION

In Table, each practice is rated with respect to fifteen separate considerations. These considerations are divided into three categories: types of control, applicability, and other considerations. Following are definitions of each consideration:

Types of Control

Control of Particulate Pollutants indicates the potential of a practice to reduce the particulate or settleable pollutant load in urban runoff.

Control of Soluble Pollutants indicates the potential of a practice to remove soluble pollutants from urban runoff.

Control of Runoff Volume and Discharge indicates the potential of a practice to reduce runoff volume or to control discharge rates through stormwater detention and/or infiltration.

TABLE 2 (Continued)

EVALUATION OF NON-STRUCTURAL AND STRUCTURAL BEST MANAGMENT PRACTICES

GENERAL EXPLANATION (Continued)

Applicability

New Development indicates the applicability of a practice in areas which are in the process of being developed to urban-type uses for the first time. Examples would include new residential subdivisions or shopping malls in previously rural areas.

Existing Development indicates the applicability of a practice in established urban areas where additional new development is unlikely.

High Density Development indicates the applicability of a practice in densely developed urban areas which consist of greater than 50 percent impervious surfaces (i.e. rooftops, pavement, etc.). Examples include city business districts, heavy commercial or industrial areas and high rise residential areas.

Low-Moderate Density Development indicates the applicability of a practice in urban areas with less than 50 percent impervious cover. Examples include suburban residential subdivisions, parks and some light commercial or industrial areas.

Site-Specific Applications indicates the applicability of a practice to control runoff of pollution problems on a single site or small drainage area basis.

Areawide Applications indicates the applicability of a practice to control runoff or pollution from large drainage areas or multi-site developments.

Other Considerations

Municipal Responsibility indicates the extent to which installation, operation and/or maintenance responsibilities are borne by the local government.

Property Owner Responsibility indicates the extent to which installation, operation and/or maintenance responsibilities are borne by an individual property owner.

TABLE 2 (Continued)

EVALUATION OF NONSTRUCTURAL AND STRUCTURAL
BEST MANAGMENT PRACTICES

GENERAL EXPLANATION (Continued)

Aesthetic/Environmental Improvement indicates the level of improvement in the attractiveness of an area resulting from the implementation of the practice.

Groundwater Pollution Potential indicates the potential for groundwater pollution as a result of practice implementation.

Maintenance Requirement indicates the relative amount of maintenance required to keep the practice functioning efficiently and effectively.

Land Requirement indicates the relative amount of surface area necessary for the installation and operation of the practice.

Each practice is generally rated with respect to each consideration by symbols which are defined as follows:

H - Denotes a high degree of control, applicability or a consideration of great significance.
M - Denotes a moderate degree of control, applicability or a consideration of some significance.
L - Denotes a low degree of control, applicability or a consideration of little significance.
V - Denotes a variable applicability or level of consideration which is dependent upon specific local conditions.
NA - Not applicable.

It should be understood that these practice ratings are tentative, somewhat subjective and difficult to define. They are intended only to represent general ranges which aid the user in evaluating alternative practices with respect to each consideration.

CHAPTER IV

AN ANALYSIS OF NONPOINT SOURCE POLLUTANT LOADINGS IN THIRD-ORDER DRAINAGE BASINS

Before developing stormwater management strategies for typical drainage basins, it was necessary to gain an understanding of the magnitude of NPS pollution associated with various types and mixes of land uses. This was done by estimating the annual NPS loadings for specific pollutants for the region's developed and developing watersheds (i.e., first-order drainage basins) and the third-order drainage basins comprising those watersheds. A map of the region's watersheds and third-order drainage basins is shown in Figure 2. NPS loadings were estimated for conventional pollutants (5-day biochemical oxygen demand, total suspended solids and fecal coliform), nutrients (total phosphorus and total nitrogen), and metals (lead and zinc). The land use categories for which loadings were estimated include commercial/institutional, light industry (includes all streets), heavy industry, low density residential, high density residential, agriculture, open and undeveloped, and water. The loading factors used in this analysis were derived from sampling and computer modelling work done in previous studies for the Hampton Roads area, Northern Virginia and the Chesapeake Bay Basin. Factors used for each pollutant parameter and land use are shown in Table 3. Except where otherwise noted, all factors are expressed in pounds per acre per year.

A number of other NPS pollutants, which may result in significant water quality problems, were not included in this analysis. These include copper, tin, polynuclear aromatic hydrocarbons and other organic substances. Local loading factors have not been developed for these pollutants due to a lack of extensive sampling data and to the site-specific nature of their discharges. Furthermore, NPS loading estimates were not generated for certain site-specific activities and land uses which are known to be significant sources of NPS pollution. These include construction sites, outside material storage sites and marinas. Construction-related loadings could not be estimated because they are sporadically located and short-term in duration. Also, impacts from construction site runoff tend to be localized. Loadings from outside storage sites cannot be generalized because they represent a wide variety of types and amounts of pollutants depending on site characteristics and the nature of the stored material. Marina NPS loadings could not be estimated because they vary significantly in size, location characteristics and clientele. For the preceding reasons, the NPS loadings calculated for this study tend to understate the region's NPS pollution problem.

For metropolitan Southeastern Virginia (Chesapeake, Norfolk, Portsmouth, Suffolk and Virginia Beach), the land use data used to estimate loadings were obtained from SVPDC's 1985 Transportation Data Report (TDR). To be of use to this study, the TDR database had to be modified in two ways. First, the TDR data were aggregated to the third-order drainage basin level. The TDR database was initially

TABLE 3
NONPOINT SOURCE LOADING FACTORS BY LAND USE CATEGORY

Parameter	Commercial/ Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agricultural	Vacant	Water
BOD	37.4(E)	21.8(A)	21.8(A)	18.7(A)	36.3(A)	45.0(F)	1.7(A)	-
TSS	0.294(E)	0.167(A)	0.167(A)	0.145(A)	0.255(A)	3.6(F)	0.012(A)	-
Fecal Coliform	153.9(E)	53.5(A)	53.5(A)	87.1(A)	361.4(A)	-	1.0(A)	-
Total P	1.53(E)	0.86(A)	0.86(A)	0.75(A)	1.34(A)	1.04(D)	0.05(A)	0.70(B)
Total N	15.1(E)	8.6(A)	8.6(A)	7.4(A)	13.2(A)	9.10(D)	0.6(A)	1.6(B)
Lead	2.17(E)	1.77(C)	1.77(C)	0.24(C)	0.67(C)	0.04(F)	0.02(C)	0.02(C)
Zinc	1.53(E)	1.40(C)	1.40(C)	0.18(C)	0.33(C)	0.22(F)	0.02(C)	0.02(C)

Notes:

1. All factors expressed in pounds per acre per year, except as otherwise noted.
2. BOD is 5-day Biochemical Oxygen Demand.
3. Total suspended solids, (TSS) expressed as Factor x 10^3.
4. Fecal coliform bacteria as 10^9 cells.
5. Total Phosphorus.
6. Total Nitrogen.
7. Fecal Coliform loading rates for agricultural land, and BOD, TSS and Fecal Coliform loading rates for water were not developed for previous studies.

Sources:

(A) Hampton Roads Water Quality Management Plan.
(B) EPA Chesapeake Bay Basin Model, reported in CDM, Water Quality Management Plan for Skiffe's Creek Reservoir Watershed.
(C) EPA Washington D.C. NURP Study, reported in CDM.
(D) State Water Control Board, Chowan Basin Nutrient Control Plan for Virginia.
(E) SVPDC, 1986. Based on average of loading rates for Commercial Strip.
(F) State Water Control Board, Chowan River Basin 208 Project.

established for transportation planning purposes and was therefore compiled for Statistical Areas (SAs). Unfortunately, SA boundaries were drawn to correspond to Census Tract and jurisdictional boundaries and not to drainage basin boundaries. It was therefore necessary to split and assign portions of some SAs to drainage basins. For each SA that required splitting, the percentage of the SA assigned to each drainage basin was determined. These percentages were then used to proportion and allocate SA land use totals to the appropriate drainage basins. Once the TDR land use data were compiled at the third-order drainage basins level, it was necessary to consolidate TDR land use categories in order that they match the categories for which the selected loading factors were developed. The methodology used in this consolidation process is shown in Table 4.

TDR land use data are not available for rural Southeastern Virginia (Franklin, Isle of Wight County and Southampton County). The most recent land use survey for this area was conducted in 1970 by the SVPDC. The 1970 database was used as a base for a series of land use projections developed in 1976 during the preparation of the Hampton Roads Water Quality Plan.[23] For the purposes of this study, projections for the year 1985 were used to estimate current NPS pollutant loadings. Because this study focuses on NPS pollution associated with developed and developing areas, it was decided to estimate loadings for the Pagan River basin only. This basin, located in rapidly growing northern Isle of Wight County, contains significant residential, commercial and industrial land use. It can reasonably be expected that urban NPS loads currently contribute significantly to water quality degradation in the Pagan River and anticipated growth will exacerbate this problem. The remainder of rural Southeastern Virginia is located within the Chowan River watershed, which contains the Blackwater, Nottoway and Meherrin river basins, or in the relatively small Lawnes Creek basin. NPS pollutant loadings were not estimated for these areas because they contain only a small amount of urban land use and vast areas of agricultural and forested lands.[24] It can therefore be assumed that urban runoff has only a very minor effect on the overall water quality of the water bodies draining these areas. It is recognized that NPS loadings from urban areas in the Chowan Basin may have significant localized impacts, especially in the tributaries to the Basin's major rivers.

The NPS pollutant loads for each of the watersheds and third order drainage basins analyzed are shown in Appendix D.

SUMMARY OF ESTIMATED NPS POLLUTANT LOADINGS

The following briefly summarizes, for each pollutant analyzed, those land uses and third-order drainage basins which produce high NPS loadings.

TABLE 4

METHODOLOGY FOR CONSOLIDATING TDR LAND USE CATEGORIES

Use Categories Used in NPS Loading Analysis	Consolidation of TDR Use Categories
Light Industrial	Manufacturing (2&3) + Trans. Comm. Util. (4) - SAs along Elizabeth R.
Heavy Industry	All subtracted items above.
Commercial/Institution	Trade (5) + Services (6) - Cemeteries (624)
Low Density Residential	Residential (1) (1-7 DU/acre)
High Density Residential	Residential (1) (>7 DU/acre)
Agriculture	Resource Prod. Ext. (8)
Open Space & Undeveloped	Undev. (9) + Cemetery (624) + Cult. Ent. & Rec. (7) - Water (93)

* All numbers in parentheses refer to Standard Land Use Code categories as used in the SVPDC Transportation Data Report (TDR).

Biochemical Oxygen Demand (BOD)

High BOD loading estimates are generally associated with agricultural as well as mixed, high density urban use. Predominantly agricultural third-order basins with high BOD loadings include those surrounding the North Landing River, Nansemond River, the Pagan River and Chuckatuck Creek. Intensely developed urban basins which produce high BOD estimates include those surrounding the Lafayette River, the Eastern and Western Branches of the Elizabeth River, the Western Branch of the Lynnhaven River, Little Creek and the Norfolk In-Town Reservoirs.

Total Suspended Solids (TSS)

Suspended Solids are generally associated with the erosion that occurs as a result of construction and agricultural activities. Because loading estimates for construction activities were not developed for this study, the highest TSS loading estimates are associated with the predominantly agricultural basins noted above in the BOD summary.

Fecal Coliforms

High fecal coliform loadings are associated with basins containing significant low and high density residential uses, and, to a lesser degree, commercial and institutional uses. These include those draining into Willoughby Bay, the Lafayette River, the Eastern Branch of the Elizabeth River, Little Creek from the Ocean View area, and Rudee Inlet.

Total Phosphorus and Total Nitrogen

Total phosphorus and total nitrogen NPS loadings are generally associated with fertilizer use. Due to a greater degree of imperviousness, high density urban development has a higher per acre loading rate than agricultural use. Therefore, basins with significant commercial/institutional and high density residential uses have the highest estimated per acre loadings for these parameters. Basins producing the highest total phosphorus and total nitrogen loadings include those draining into Willoughby Bay, the Lafayette River, the Eastern Branch of the Elizabeth River, the Nansemond River from downtown Suffolk, the Western Branch of the Lynnhaven River, Little Creek and Rudee Inlet.

Lead and Zinc

Lead and zinc loads in urban runoff are primarily generated by motor vehicles. Basins with a large amount of traffic-generating land use, such as commercial/institutional and industrial, will therefore produce the highest loading estimates. Basins with particularly high lead and zinc loading estimates include those surrounding Willoughby Bay, the Eastern Branch of the Elizabeth River and the Norfolk In-Town Reservoirs.

A COMPARISON OF NONPOINT SOURCE LOADINGS AND SEWAGE TREATMENT PLANT DISCHARGES

In order to demonstrate the magnitude of the NPS pollution problem, a comparison was made of estimated NPS loadings from the Lynnhaven River Basin and discharges from a hypothetical sewage treatment plant (STP) having sufficient capacity to serve the population within that basin. The Lynnhaven River basin was chosen for this comparison because it contains a typical mix of urban land uses. In reality, the Lynnhaven River system does not receive STP discharges. All point source discharges to the Lynnhaven River have been eliminated. The Basin is served by private septic systems and two Hampton Roads Sanitation District (HRSD) STPs, Chesapeake-Elizabeth and Atlantic, which discharge into the Chesapeake Bay and the Atlantic Ocean respectively.

Estimated NPS loadings for the Lynnhaven River Basin and the land use totals from which they were derived are shown in Table 5. In estimating the loadings associated with a hypothetical STP, a wastewater generation and treatment rate of 100 gallons per person per day was assumed. Using an estimated basinwide 1980 population of 144,686, it was determined that, to adequately serve the basin, a 14.47 million gallon per day (MGD) STP would be required.[25] It was assumed that this plant would provide advanced secondary treatment with biological nutrient removal. In determining a realistic size for the hypothetical STP, it was acknowledged that some areas of the Lynnhaven Basin are still served by private septic systems. However, the proportion of the basin's population relying on septic systems is small and it is anticipated that public sewer lines will be extended into currently unserved areas in the near future. Furthermore, a significant amount of growth occurred in the Lynnhaven River basin between 1980, the year for which the population-based STP loadings were calculated, and 1985, the year for which the land use-based NPS loadings were calculated. Including that portion of the population served by septic systems in the basin population totals helps compensate for the increase in population between 1980 and 1985.

The factors used to calculate pollutant loadings for the hypothetical "Lynnhaven River STP" are shown in Table 6. These factors, which were provided by the HRSD Water Quality Department, reflect reasonable operational levels for advanced secondary treatment. Loading factors for fecal coliform were not developed because the chlorination process found in all STPs virtually eliminates this pollutant. The loading factors, expressed in milligrams per liter per day, were converted to loadings in pounds per year for the hypothetical 14.47 MGD plant. These loadings are compared to estimated NPS loadings in the Lynnhaven River basin in Figure 3.

TABLE 5
LYNNHAVEN RIVER BASIN
ESTIMATED ANNUAL NONPOINT SOURCE LOADS

Parameter	Commercial/ Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agricultural	Undeveloped	Water	Total
BOD	88,509.91	128,972.07	0.00	211,878.11	102,357.65	82,503.00	25,306.30	0.00	639,527.03
TSS	695.77	988.00	0.00	1,642.91	719.04	6,600.24	178.63	0.00	10,824.59
Fecal Coliform	364,215.89	316,514.02	0.00	986,876.10	1,019,064.88	0.00	14,886.06	0.00	2,701,556.95
Total P	3,620.86	5,087.89	0.00	8,497.79	3,778.49	1,906.74	744.30	3,647.11	27,283.18
Total N	35,735.28	50,878.89	0.00	83,844.81	37,220.96	16,683.94	8,931.64	8,336.26	241,631.78
Lead	5,135.47	10,471.59	0.00	2,719.29	1,889.25	73.34	297.72	104.20	20,690.85
Zinc	3,620.86	8,282.61	0.00	2,039.47	930.52	403.35	297.72	104.20	15,678.73
1985 Land Use									
Acres	2,366.58	5,916.15	0.00	11,330.38	2,819.77	1,833.40	14,886.06	5,210.16	44,376.60
Percent	5.33	13.33	0.00	25.53	6.35	4.13	33.54	11.74	100.00

Notes:

1. All loadings are expressed in pounds per year, except where otherwise noted.
2. BOD is 5-day Biochemical Oxygen Demand.
3. Total Suspended Solids (TSS) is expressed in thousands.
4. Fecal Coliform is expressed in 10^9 Cells.
5. Total P = Total Phophorus.
6. Total N = Total Nitrogen.
7. Fecal Coliform loadings were not calculated for agricultural land use, and BOD, TSS and Fecal Coliform loadings were not calculated for water.

Source: SVPDC, 1989.

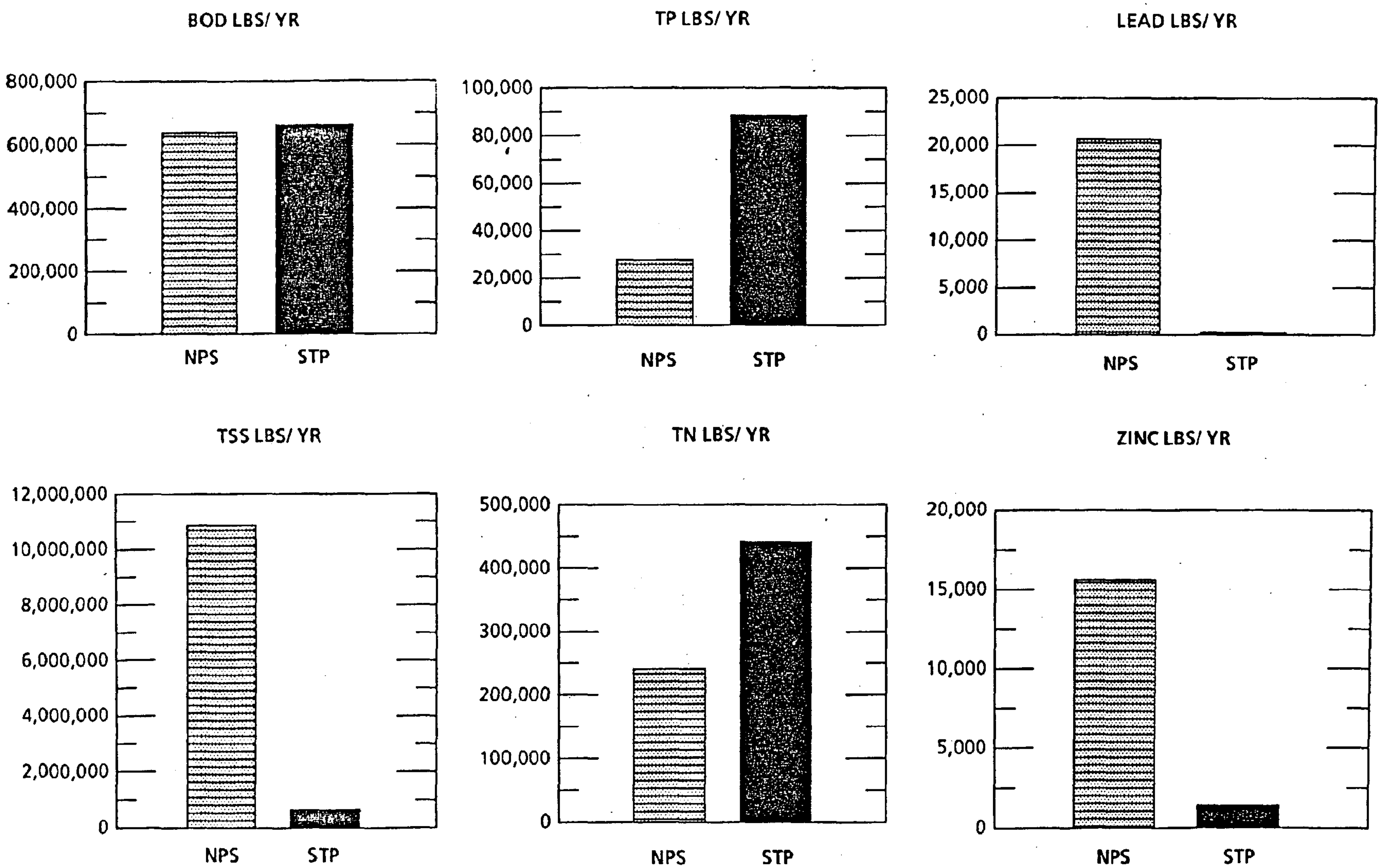
TABLE 6

POLLUTANT LOADING FACTORS FOR HYPOTHETICAL "LYNNHAVEN RIVER SEWAGE TREATMENT PLANT"

Parameter	Loading Factor
BOD	15 mg/liter
TSS	15 mg/liter
Total P	10 mg/liter
Total N	2 mg/liter
Lead	.031 mg/liter
Zinc	.0025 mg/liter

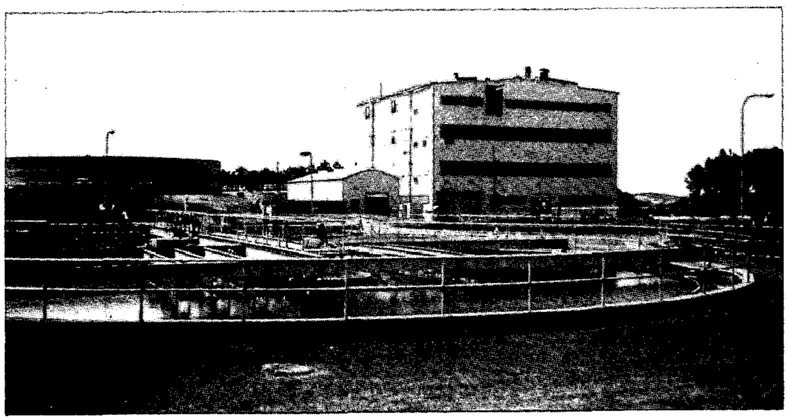
Source: Hampton Roads Sanitation District, 1987 & 1989.

FIGURE 3
COMPARISON OF ESTIMATED NONPOINT SOURCE LOADS WITH LOADS FROM A HYPOTHETICAL SEWAGE TREATMENT PLANT IN THE LYNNHAVEN BASIN



Source: *SVPDC and HRSD, 1989.*

As can be seen from the hypothetical situation reflected in the loading comparison, nonpoint sources contribute significantly to overall pollutant loadings. Nonpoint source BOD loadings would be on par with STP loadings, and nonpoint source TSS, lead and zinc loadings would far exceed those for STPs. Total phosphorus and total nitrogen are the only pollutants for which STP loadings would significantly exceed NPS loadings. But even for these parameters, nonpoint sources would account for a significant proportion of total loadings (24% of the total phosphorus load and 35% of the total nitrogen load). Since there are no STPs discharging to the Lynnhaven River, nonpoint sources, including transient vessels and natural sources constitute the only contributors to pollutant loadings.



The preceding analysis illustrates the extent to which NPS pollution can contribute to total pollutant loadings. The degree of water quality degradation attributable to NPS pollution will depend on the specific land and water characteristics of individual drainage basins. It is safe to conclude, however, that, due to NPS pollution, maximum control or elimination of point sources in urbanized watersheds cannot fully resolve water quality problems.

CHAPTER V

STORMWATER CONTROL STRATEGIES FOR TYPICAL FOURTH-ORDER WATERSHEDS

In order to evaluate and develop control strategies for nonpoint sources on a small scale, a series of fourth-order "typical watersheds" have been identified. These watersheds represent a range of concentrated and mixed land use types. The typical watersheds included in this analysis are listed below. Their locations can be seen in Figure 4.

- Urban/downtown residential (the Ghent area of Norfolk).
- Low density residential (the upper Lynnhaven area of Virginia Beach).
- Mixed commercial (the Military Circle/Koger Office Park area of Norfolk).
- Light industry (the Airport Industrial Park area of Virginia Beach).
- Military (the Little Creek Naval Amphibious Base in Virginia Beach).
- Urban/downtown commercial (the central business district area of Norfolk).
- Heavy industry (the industrialized area on the eastern shore of the Elizabeth River Southern Branch in Norfolk).

By examining these smaller scale watersheds from the perspective of what can be done to minimize NPS pollution, insights may be gained into what can be done on a larger watershed basis to meet pollutant reduction goals. Using the methodology described in the previous chapter for third-order drainage basins, typical fourth-order watershed boundaries were identified and estimated annual NPS loadings were developed. The typical watershed land use data and loading information is found in Tables 7 through 13.

To better understand of the significance of stormwater- borne pollutant loads, Figures 5 through 10 display estimated annual parameter loadings for each typical watershed compared with the annual loading of that parameter which could be expected from a one (1) MGD sewage treatment plant. Such a sewage treatment plant would have a service population of approximately ten thousand (10,000) people. While not all of the typical watersheds would have that population, it serves as a useful and approximate comparison of pollutant loads likely to come from both types of sources for similarly sized areas. Since instream nonpoint source impact sampling and analysis is not a part of this study, the STP comparison also helps draw conclusions regarding instream impacts of typical nonpoint source watershed loadings.

TABLE 7
TYPICAL WATERSHED
ANNUAL NONPOINT SOURCE LOADINGS
1985 LAND USE
DOWNTOWN RESIDENTIAL - GHENT

	Commercial and Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agriculture	Open and Undeveloped	Water	Total	Loadings Per Acre
Land Use										
Total Acreage	158.6	185.0	--	--	160.8	--	91.7	10.7	606.8	
Percent of Basin	26.0	30.0	--	--	27.0	--	15.0	2.0		
Parameter Loadings										
BOD	5,931.6	4,033.0	--	--	5,837.0	--	155.9	--	15,957.5	26.3
TSS	46,628.4	30,895.0	--	--	41,004.0	--	1,100.4	--	119,627.8	197.0
Fecal Coliform	24,408.5	9,897.5	--	--	58,113.1	--	91.7	--	92,510.8	--
Total Phosphorus	242.6	159.1	--	--	215.5	--	4.6	7.5	629.3	1.0
Total Nitrogen	2,394.9	1,591	--	--	2,122.6	--	55.0	17.1	6,180.6	10.2
Lead	344.2	327.5	--	--	107.7	--	1.8	19.3	800.5	1.3
Zinc	242.6	259.0	--	--	53.0	--	1.8	19.3	575.7	1.0

Note: All loadings expressed in pounds per year, except Fecal Coliform which is expressed as 10^9 cells.

Source: SVPDC and HRWQA, 1989.

TABLE 8
TYPICAL WATERSHED
ANNUAL NONPOINT SOURCE LOADINGS
1985 LAND USE
LOW DENSITY RESIDENTIAL - LYNNHAVEN

	Commercial and Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agriculture	Open and Undeveloped	Water	Total	Loadings Per Acre
Land Use										
Total Acreage	156.2	316.8	--	1,462.4	--	136.9	818.4	1,320.0	4,210.7	
Percent of Basin	3.7	7.5	--	34.7	--	3.3	19.4	31.3		
Parameter Loadings										
BOD	5,841.9	6,906.2	--	27,346.9	--	6,160.5	1,391.3	--	47,646.8	11.3
TSS	45,922.8	52,905.6	--	212,048.0	--	492,840.0	9,820.8	--	813,537.0	193.2
Fecal Coliform	24,038.2	16,918.8	--	127,375.0	--	--	818.4	--	169,150.5	--
Total Phosphorus	239.0	272.0	--	1,096.8	--	142.4	40.9	924.0	2,715.1	0.6
Total Nitrogen	2,358.6	2,719.7	--	10,821.8	--	1,245.8	491.0	2,112.0	19,748.9	4.7
Lead	339.0	559.7	--	351.0	--	5.5	16.4	26.4	1,297.9	0.3
Zinc	239.0	442.7	--	263.2	--	30.1	16.4	26.4	1,017.9	0.2

Note: *All loadings expressed in pounds per year, except Fecal Coliform which is expressed as 10^9 cells.*

Source: SVPDC and HRWQA, 1989.

TABLE 9

TYPICAL WATERSHED

ANNUAL NONPOINT SOURCE LOADINGS

1985 LAND USE

MIXED COMMERCIAL - MILITARY CIRCLE/KOGER

	Commercial and Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agriculture	Open and Undeveloped	Water	Total	Loadings Per Acre
Land Use										
Total Acreage	387.3	263.9	--	146.3	40.9	0.6	301.4	80.9	1,221.3	
Percent of Basin	31.7	21.6	--	12.0	3.3	0.1	24.7	6.6		
Parameter Loadings										
BOD	14,485.0	5,753.0	--	2,735.8	1,484.7	27.0	512.4	--	24,997.9	20.5
TSS	113,866.2	44,071.3	--	21,213.5	10,429.5	2,160.0	3.6	--	195,357.0	155.0
Fecal Coliform	59,605.5	14,118.6	--	12,742.7	14,781.3	--	301.4	--	101,549.5	--
Total Phosphorus	592.6	226.9	--	109.7	54.8	0.6	15.0	56.6	1,056.2	0.9
Total Nitrogen	5,848.2	2,269.5	--	1,082.6	539.9	5.5	180.8	129.4	10,055.8	8.2
Lead	840.0	467.1	--	35.1	27.4	--	6.0	1.6	1,377.2	1.1
Zinc	592.6	369.5	--	26.3	13.5	0.1	6.0	1.6	1,009.6	0.8

Note: All loadings expressed in pounds per year, except Fecal Coliform which is expressed as 10^9 cells.

Source: SVPDC and HRWQA, 1989.

TABLE 10

TYPICAL WATERSHED

ANNUAL NONPOINT SOURCE LOADINGS

1985 LAND USE

LIGHT INDUSTRY - AIRPORT INDUSTRIAL PARK

	Commercial and Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agriculture	Open and Undeveloped	Water	Total	Loadings Per Acre
Land Use										
Total Acreage	130.7	149.8	--	39.7	--	4.6	109.6	19.7	454.1	
Percent of Basin	*29.0*	*33.0*	--	9.0	--	1.0	24.0	4.0		
Parameter Loadings										
BOD	4,888.2	3,265.6	--	742.4	--	207.0	186.3	--	9,289.5	20.5
TSS	38,425.8	25,016.6	--	5,756.5	--	16,560.0	1,315.2	--	87,074.0	192.0
Fecal Coliform	20,114.7	8,014.3	--	3,457.9	--	--	109.6	--	31,696.5	--
Total Phosphorus	200.0	128.8	--	29.8	--	4.8	5.5	13.8	382.7	0.8
Total Nitrogen	1,973.6	1,288.3	--	293.8	--	41.9	65.8	31.5	3,694.9	8.1
Lead	283.6	265.1	--	9.5	--	0.2	2.2	0.4	561.0	1.2
Zinc	200.0	209.7	--	7.1	--	1.0	2.2	0.4	420.4	0.9

Note: *All loadings expressed in pounds per year, except Fecal Coliform which is expressed as 10^9 cells.*

Source: SVPDC and HRWQA, 1989.

TABLE 11
TYPICAL WATERSHED
ANNUAL NONPOINT SOURCE LOADINGS
1985 LAND USE
MILITARY - LITTLE CREEK

	Commercial and Institutional	*Light* Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agriculture	Open and Undeveloped	Water	Total	Loadings Per Acre
Land Use										
Total Acreage	241.8	358.8	--	206.9	--	--	1,109.9	469.0	2,386.4	
Percent of Basin	10.0	15.0	--	8.0	--	--	47.0	20.0		
Parameter Loadings										
BOD	9,043.3	7,821.8	--	3,869.0	--	--	1,886.8	--	22,620.9	9.5
TSS	71,089.2	59,919.6	--	30,000.5	--	--	13,318.8	--	174.328.1	73.0
Fecal Coliform	37,213.0	19,195.8	--	18,021.0	--	--	1,109.9	--	75,539.7	--
Total Phosphorus	369.9	308.6	--	155.2	--	--	55.5	328.3	1,217.5	0.5
Total Nitrogen	3,651.2	3,085.6	--	1,531.1	--	--	665.9	750.4	9,684.2	4.1
Lead	524.7	635.1	--	49.7	--	--	22.2	9.4	1,241.1	0.5
Zinc	369.9	502.3	--	37.2	--	--	22.2	9.4	941.0	0.4

Note: *All loadings expressed in pounds per year, except Fecal Coliform which is expressed as 10^9 cells.*

Source: SVPDC and HRWQA, 1989.

TABLE 12
TYPICAL WATERSHED
ANNUAL NONPOINT SOURCE LOADINGS
1985 LAND USE
DOWNTOWN COMMERCIAL - NORFOLK CBD

	Commercial and Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agriculture	Open and Undeveloped	Water	Total	Loadings Per Acre
Land Use										
Total Acreage	115.2	81.7	52.9	11.3	7.1	--	74.6	67.8	410.6	
Percent of Basin	28.0	20.0	12.0	3.0	2.0	--	18.0	17.0		
Parameter Loadings										
BOD	4,308.5	1,781.1	1,153.2	211.3	257.7	--	126.8	--	7,838.6	19.1
TSS	33,868.8	13,643.9	8,834.3	1,638.5	1,810.5	--	895.2	--	31,130.9	76.0
Fecal Coliform	17,729.3	4,370.9	2,830.2	984.2	2,565.9	--	74.6	--	28,555.1	--
Total Phosphorus	176.3	70.3	45.5	8.5	9.5	--	3.7	47.5	361.3	0.9
Total Nitrogen	1,739.5	702.6	454.9	83.6	93.7	--	44.7	108.5	3,227.5	7.9
Lead	250.0	144.6	93.6	2.7	4.7	--	1.5	1.4	498.5	1.2
Zinc	176.3	114.4	74.0	2.0	2.3	--	1.5	1.4	371.9	0.9

Note: *All loadings expressed in pounds per year, except Fecal Coliform which is expressed as 10^9 cells.*

Source: *SVPDC and HRWQA, 1989.*

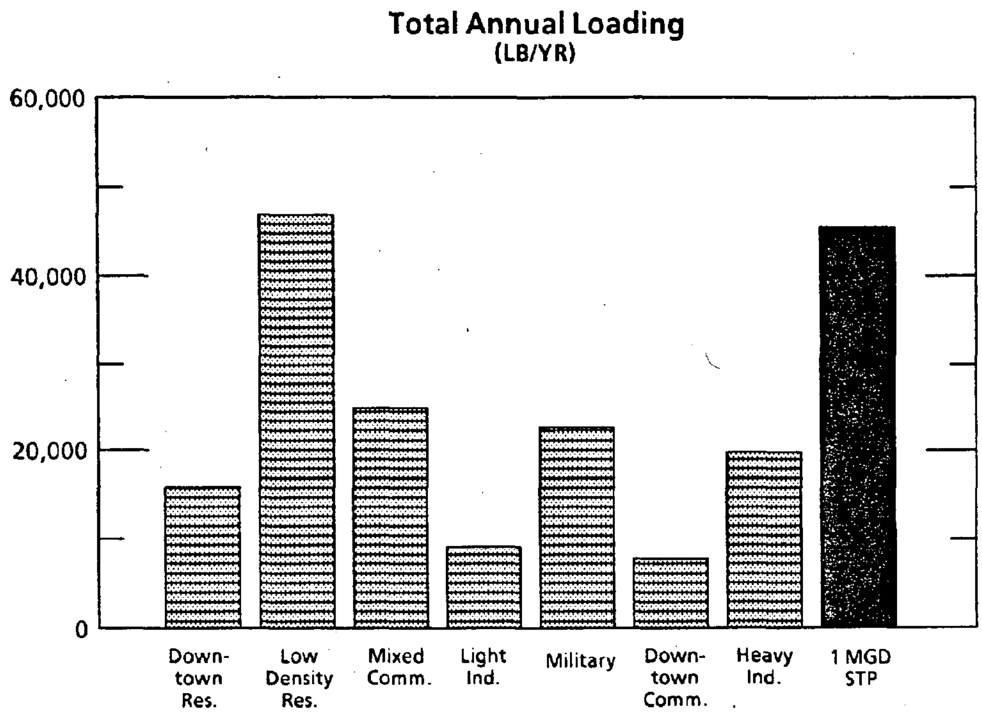
TABLE 13
TYPICAL WATERSHED
ANNUAL NONPOINT SOURCE LOADINGS
1985 LAND USE
HEAVY INDUSTRY - NORSHIPCO AREA

	Commercial and Institutional	Light Industry/ Streets	Heavy Industry	Low Density Residential	High Density Residential	Agriculture	Open and Undeveloped	Water	Total	Loadings Per Acre
Land Use										
Total Acreage	135.7	48.7	405.6	10.6	110.3	--	269.5	235.3	1,215.7	
Percent of Basin	12.0	4.0	33.0	1.0	9.0	--	22.0	19.0		
Parameter Loadings										
BOD	5,075.2	1,061.7	8,842.1	198.2	4,003.9	--	458.2	--	19,639.2	16.2
TSS	39,895.8	8,132.9	67,735.2	1,537.0	28,126.5	--	3,234.0	--	148,661.4	122.0
Fecal Coliform	20,884.2	2,605.4	21,699.6	923.3	39,862.4	--	269.5	--	86,244.4	--
Total Phosphorus	207.6	41.9	348.8	7.9	147.8	--	13.5	164.7	932.2	0.8
Total Nitrogen	2,049.0	418.8	3,488.2	78.4	1,456.0	--	161.7	376.5	8,028.6	6.6
Lead	294.5	86.2	717.9	2.5	73.9	--	5.4	4.7	1,185.1	1.0
Zinc	207.6	68.2	568.0	1.9	36.4	--	5.4	4.7	892.2	0.9

Note: *All loadings expressed in pounds per year, except Fecal Coliform which is expressed as 10^9 cells.*

Source: SVPDC and HRWQA, 1989.

FIGURE 5
TYPICAL WATERSHED ANNUAL LOADINGS COMPARED TO A ONE (1) MGD SEWAGE TREATMENT PLANT
BIOLOGICAL OXYGEN DEMAND



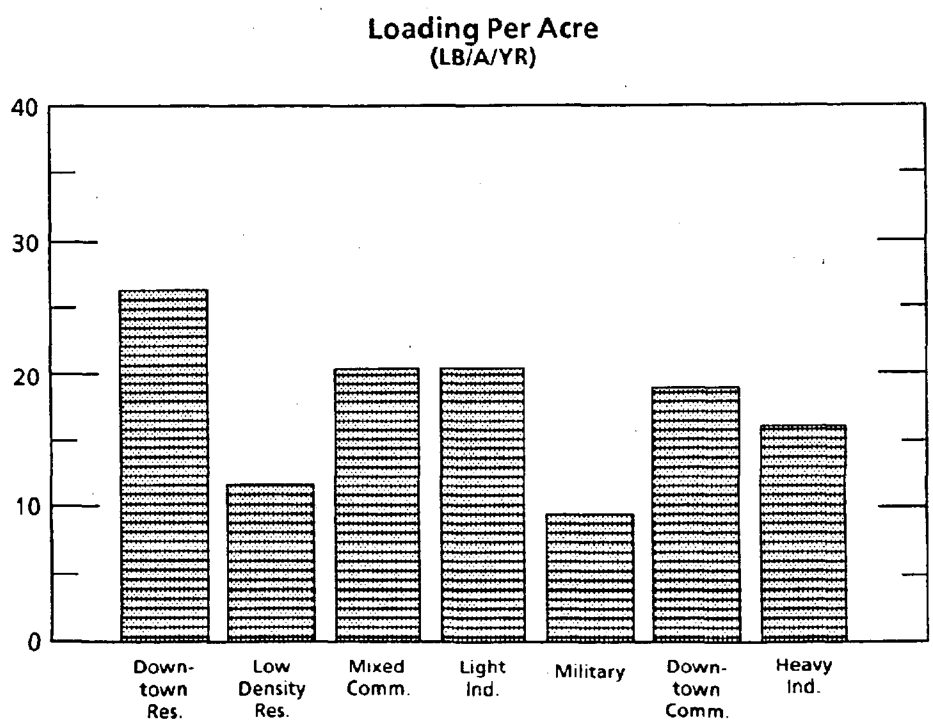
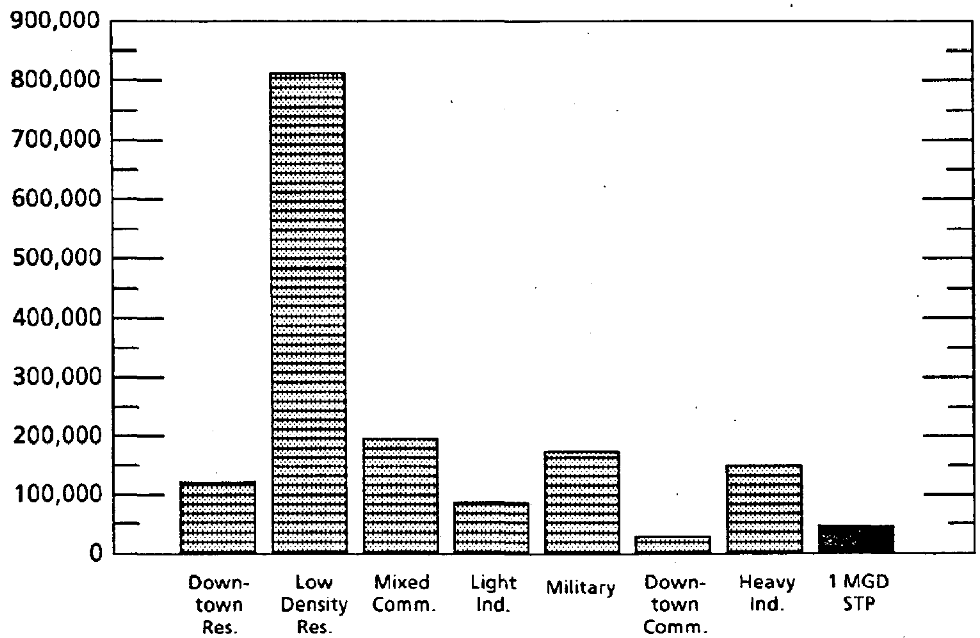


FIGURE 6
TYPICAL WATERSHED ANNUAL LOADINGS COMPARED TO A ONE (1) MGD SEWAGE TREATMENT PLANT
TOTAL SUSPENDED SOLIDS

Total Annual Loading
(LB/YR)



Loading Per Acre
(LB/A/YR)

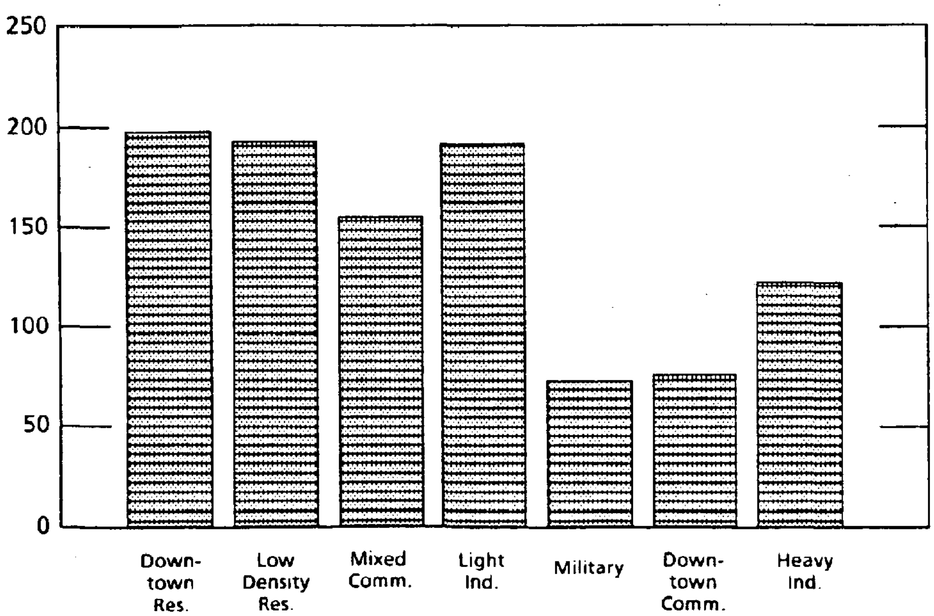
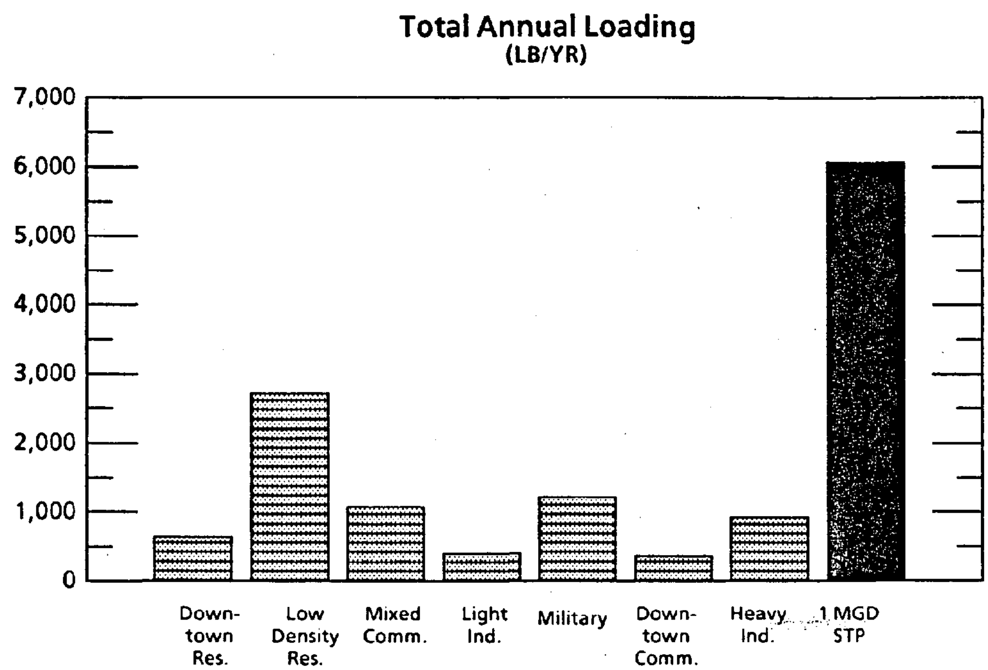


FIGURE 7
TYPICAL WATERSHED ANNUAL LOADINGS COMPARED TO A ONE (1) MGD SEWAGE TREATMENT PLANT
TOTAL PHOSPHORUS



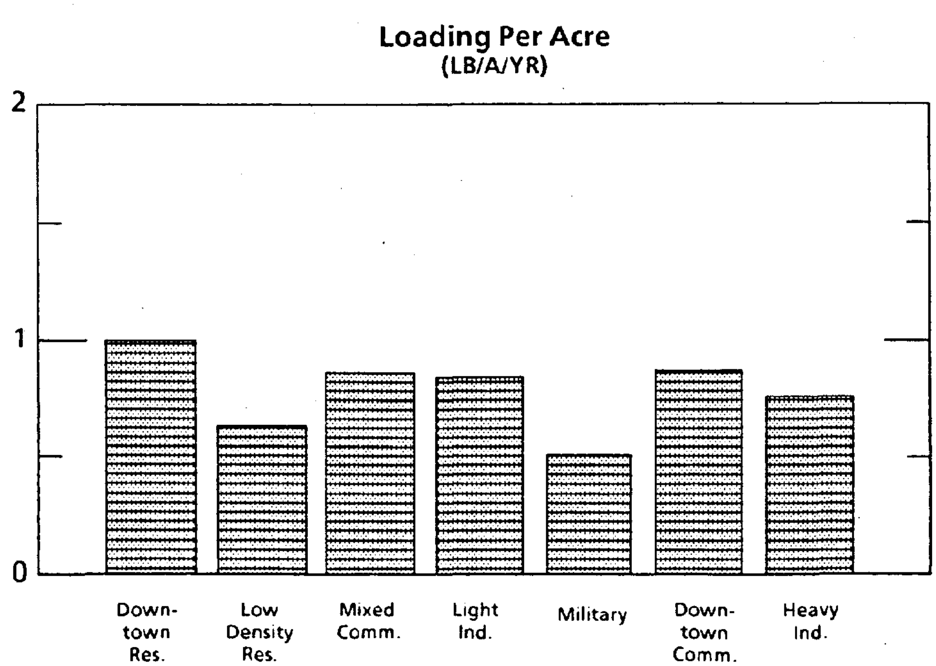
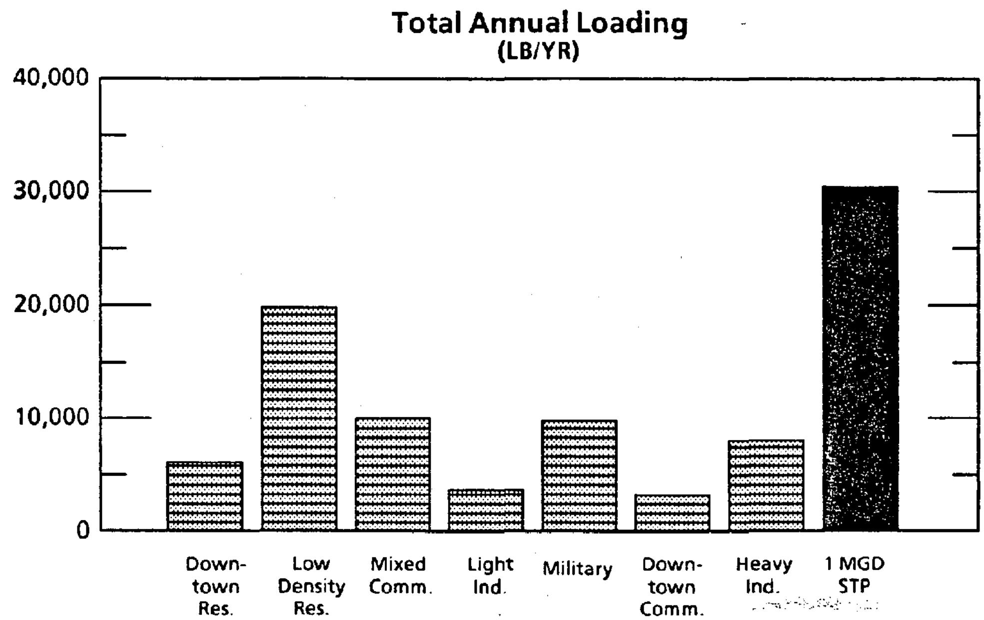


FIGURE 8
TYPICAL WATERSHED ANNUAL LOADINGS COMPARED TO A ONE (1) MGD SEWAGE TREATMENT PLANT
TOTAL NITROGEN



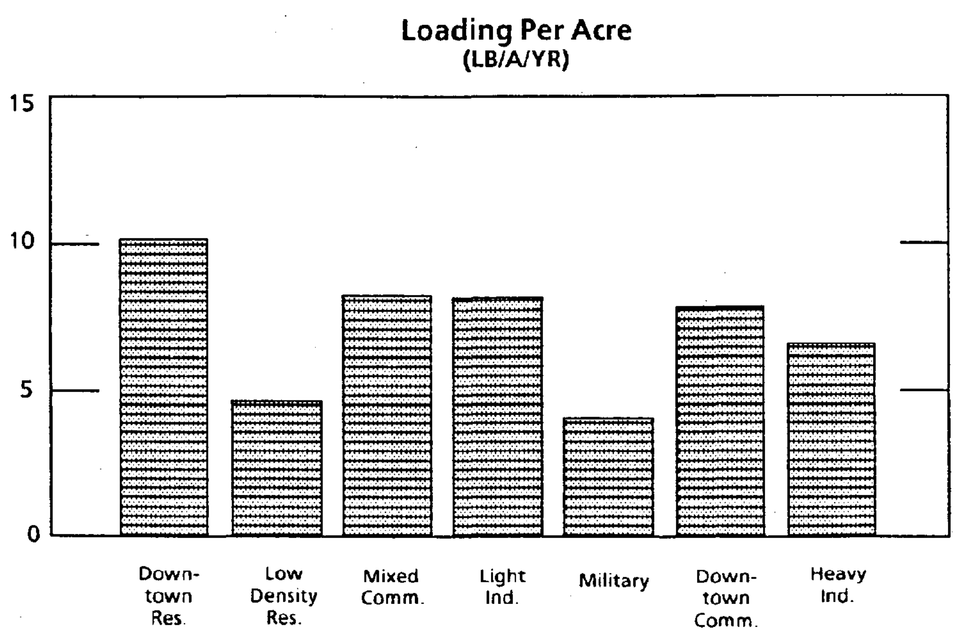
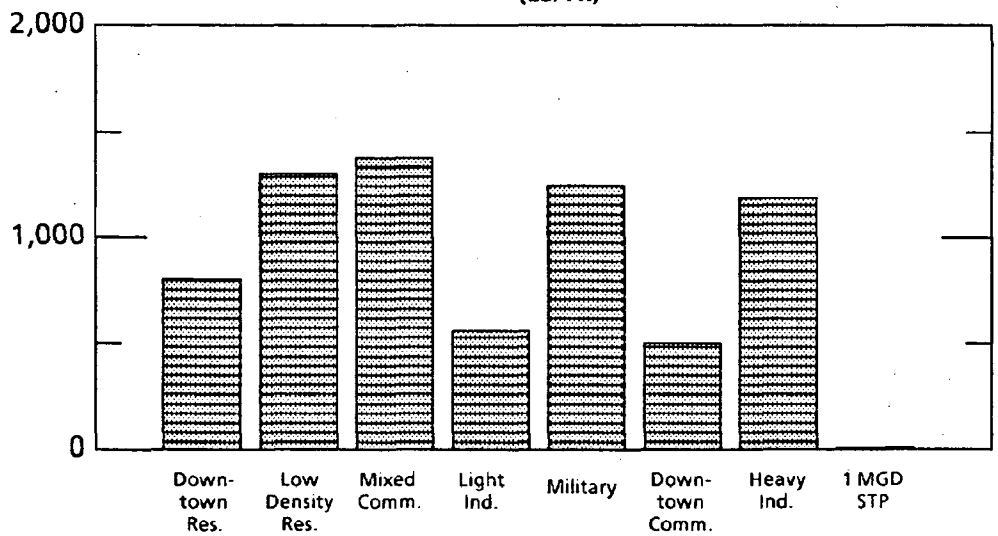


FIGURE 9

TYPICAL WATERSHED ANNUAL LOADINGS COMPARED TO A ONE (1) MGD SEWAGE TREATMENT PLANT

LEAD

Total Annual Loading
(LB/YR)



Loading Per Acre
(LB/A/YR)

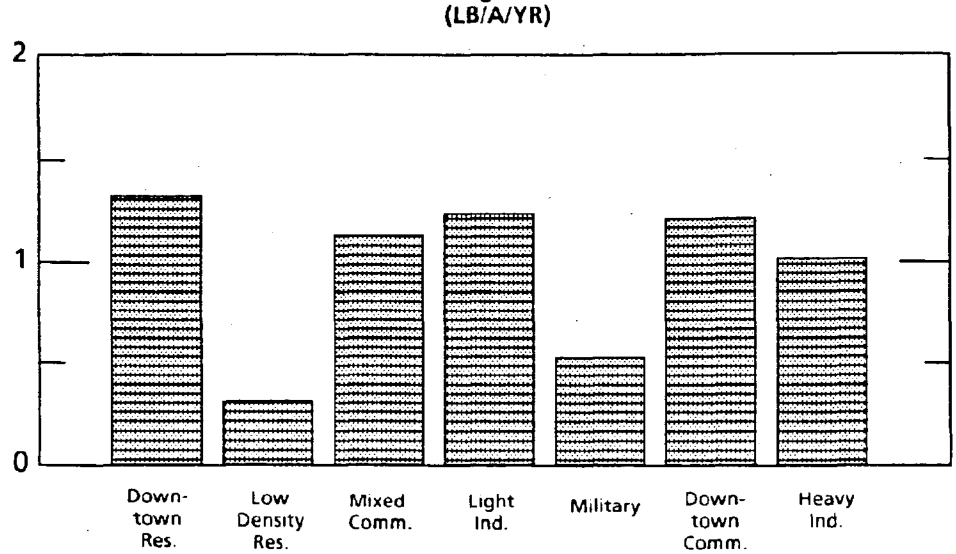
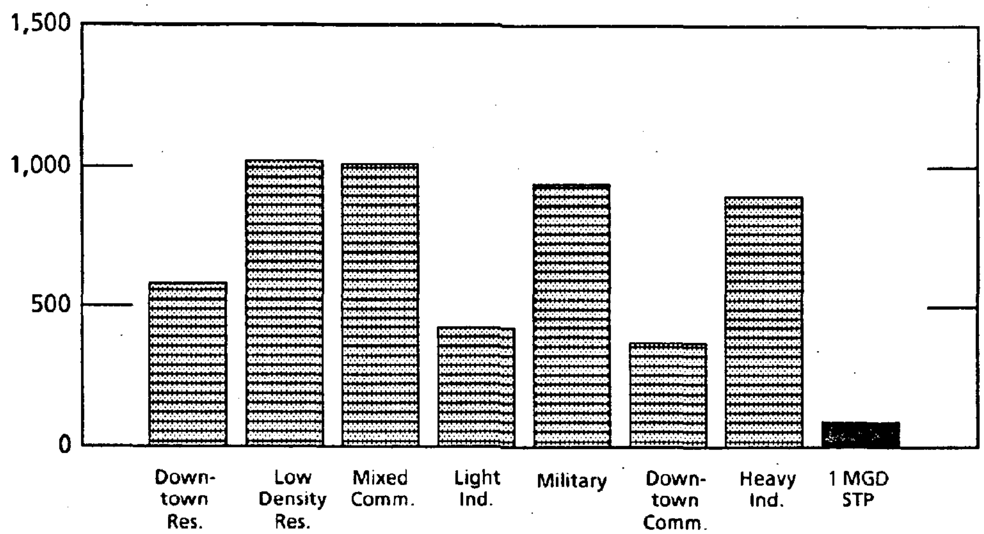
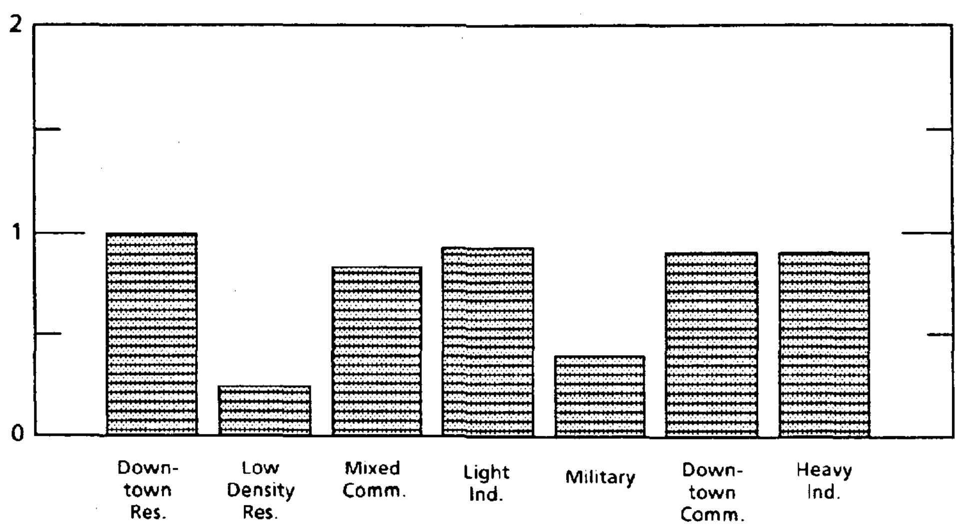


FIGURE 10
TYPICAL WATERSHED ANNUAL LOADINGS COMPARED TO A ONE (1) MGD SEWAGE TREATMENT PLANT
ZINC

Total Annual Loading
(LB/YR)



Loading Per Acre
(LB/A/YR)



NOTES TO FIGURES 5-10

Hypothetical one (1) MGD municipal sewage treatment plant - service population approximately 10,000.

Operation based on advanced secondary treatment with biological nutrient removal:

EFFLUENT CHARACTERIZATION

BOD (1)	15 mg/1
TSS (1)	15 mg/1
TN (1)	10 mg/1
TP (1)	2 mg/1
LEAD (2)	0.0025 mg/1
ZINC (2)	0.03 mg/1

(1) Reasonably expected operating levels provided by HRSD Director of Water Quality.

(2) Based on average for all nine (9) HRSD STPs as reported in 1987 Wastewater Characterization Report.

Each typical watershed discussion which follows contains three sections; a general description, a general water quality impact discussion, and recommended NPS management strategies. In the case of the latter, recommended strategies were selected from the inventory of NPS control strategies presented in Chapter III of this report. This inventory should be consulted for more details concerning the strategies recommended for each typical watershed.

TYPICAL WATERSHED - URBAN DOWNTOWN RESIDENTIAL (GHENT)

Description

This watershed includes parts of the Ghent and Ghent Square neighborhoods as well as some surrounding area. The watershed is generally bounded by Hampton Boulevard on the west; the railroad track paralleling 23rd Street on the north; Monticello Avenue on the east; and Virginia Beach Boulevard and Mowbray Arch on the south. The major points of stormwater discharge are to the Hague (Smith Creek), a tributary to the main stem of the Elizabeth River.

Land use in the watershed is a mix of commercial, institutional, residential, light industrial and open/undeveloped uses typical of an urban center's periphery area. Residential land uses are dominant and range from high density large single family homes to high density multi-story apartment buildings. A portion of the Sentara-Norfolk General Hospital complex is also in this area. As with land use acreages for all of the typical basins in this report, the light industrial category includes streets and highways. Consequently, given the urban nature of this basin with a large amount of street coverage, a high acreage amount for light industry is reported even though actual industry accounts for a relatively small part of the land use. Total acreage in the watershed is approximately 606 acres. Land use totals and NPS source loadings are presented in Table 7.

NPS Pollution Impacts

Compared to the other typical watersheds, per acre pollutant loadings for all parameters are very high. This is typical of densely developed areas. On an annual basis, the watershed contributes more TSS to the River than would a one MGD STP. However, as with all the typical watersheds, nutrient loadings would be less than the one MGD STP. As with the other typical watersheds, zinc and lead in stormwater runoff are far greater than the levels expected from the STP. The area to which stormwater is discharged from this watershed is completely bulkheaded and has little or no wetland habitat areas. Nonpoint loading impacts to this area could affect benthic life and conditions, such as species diversity and nutrient stockpiling, and also affect transitting finfish.

Recommended NPS Management Strategies

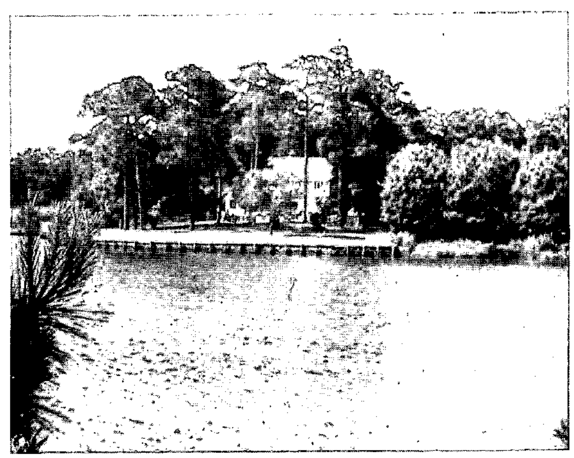
Very little developable land remains in this watershed which limits the types of BMPs that can be implemented. In this and in the other typicial watersheds, infiltration trenches and basins are infeasible due to the high groundwater table. The following recommendations should be considered for urban, high density residential areas.

- Where possible, retain filter strips and permeable areas in all redevelopment and new development.
- For low volume traffic areas, consider the use of porous pavement.
- Establish educational programs through local civic associations promoting "good housekeeping" practices to reduce NPS pollution. These practices include recycling; proper storage, use and disposal of hazardous materials; proper fertilizer use; proper vehicle maintenance; low maintenance landscaping to prevent erosion; and proper disposal of pet wastes.

TYPICAL WATERSHED - LOW DENSITY RESIDENTIAL (UPPER LYNNHAVEN RIVER)

Description

Located in Virginia Beach, this 4,211 acre (6.6 square mile) basin includes most of the Eastern Branch of the Lynnhaven River and its watershed. This area is roughly bounded by Shore Drive on the north; Virginia Beach Boulevard on the south; Great Neck Road on the east; and Little Neck Road on the west. There is a relatively even distribution of stormwater outfalls along the eastern branch and its tributaries. Many areas in this basin are served by drainage lakes which are tributary to the Lynnhaven River system. These lakes, though originally created for flood control and aesthetic purposes, provide some degree of NPS pollution control.



The dominant physical feature of this basin is the Eastern Branch of the Lynnhaven River which flows south to north through the basin. Extensive areas of marsh and tidal mudflats are associated with this waterway. The developable portions of this watershed are nearly built-out. Land use is primarily low density residential which, for the purposes of this study, is defined as less than seven units per acre. Low density residential use in this basin is comprised mainly of large-lot subdivisions and waterfront estates. Some medium density residential use is located in the southern portion of the basin and intensive strip commercial use occurs along major thoroughfares (Virginia Beach Boulevard, Great Neck Road and Shore Drive). Land use and estimated NPS loading data for this basin are shown in Table 8.

NPS Pollution Impacts

Compared to other developed basins in the region, estimated average per acre NPS loads to this basin are low to moderate. This is because of the limited amount of impervious surface and the relatively low intensity of human activity generally associated with low density residential land use. However, NPS water quality problems are a function of both pollutant loadings and the ability of a stream to assimilate pollutants. Because of the Lynnhaven's limited pollutant assimilation capacity, NPS pollution has resulted in significant water quality degradation. The major water quality problems associated with nonpoint sources include excessive siltation, high bacterial levels and nutrient enrichment. Siltation has decreased water depth which has not only impeded navigation but, by reducing tidal exchange, has also decreased the river's ability to assimilate pollutants. Bacterial contamination, as indicated by high fecal coliform levels, has resulted in the closure of nearly all shellfish grounds in the Lynnhaven system. Oxygen supersaturation and elevated chlorophyll "a" values, indicators of nutrient enrichment, have been recorded in the Lynnhaven.[26] One possible explanation for nutrient enrichment is the long term effects of nutrients trapped in the layers of bottom sediment produced by excessive siltation.[27] Over time, these nutrients may be released back into the water column.

Estimated annual NPS loadings from this basin for BOD, TSS, lead and zinc far exceed expected loadings from a one MGD STP. Total phosphorus and total nitrogen NPS loadings from this basin are also significant in that they are both greater than 50% of the expected STP loadings for the same pollutants.

Recommended NPS Management Strategies

It is expected that extensive areas along and adjacent to the tidal shoreline in this watershed will be designated as Preservation Areas in accordance with the Chesapeake Bay Preservation Act (CBPA). These areas will be subject to regulations which will soon be adopted by the Chesapeake Bay Local Assistance Board and will eventually be incorporated into Virginia Beach's land use controls. These regulations will establish performance criteria for new development, redevelopment and any other activities within the designated Preservation Areas. The proposed performance criteria will provide NPS control benefits by setting requirements for site disturbance, BMP selection, site plan reviews, septic systems, post- development stormwater runoff loads, allowable land uses, nontidal wetlands and buffer zones. Although these criteria are aimed at preventing NPS pollution, they may actually preclude the development of some BMPs, such as wet detention ponds, that would otherwise be built in Preservation Areas.

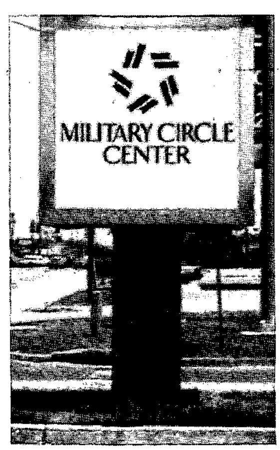
Because this basin is nearly fully developed, opportunities for the implementation of NPS control strategies in addition to those that will be required under the CBPA are limited. The following recommendations should be considered to control NPS pollution in this and in other nearly developed low density residential basins.

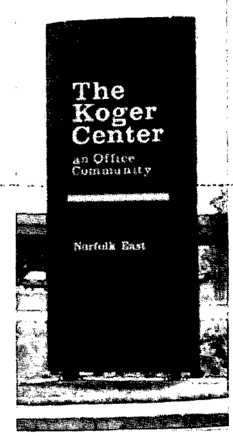
- Where sufficient land is available, encourage use of wet detention basins with extended detention devices as the preferred NPS control option.
- Retrofit existing wet detention basins with extended detention devices.
- Improve inspection and maintenance of public BMP structures and perhaps require owners of private facilities to do the same.
- In areas not served by sanitary sewers, establish onsite sewage treatment management districts to promote the proper operation and maintenance of septic systems.
- Establish educational programs through local civic associations promoting "good housekeeping" practices to reduce NPS pollution. These practices include recycling; proper storage, use and disposal of hazardous materials; proper fertilizer use; proper vehicle maintenance; low maintenance landscaping to prevent erosion; and proper disposal of pet wastes.

TYPICAL WATERSHED - MIXED COMMERCIAL (MILITARY CIRCLE-KOGER AREA)

Description

This watershed includes the Military Circle Mall and surrounding strip commercial areas, and the Koger Executive Center. The watershed is generally bounded on the west by Military Highway; Virginia Beach Boulevard on the north; on the east by a line approximately 1600 feet east of and parallel to Newtown Road; and on the south by Curlew Drive and Southern Boulevard. The major point of stormwater discharge is to an unnamed tributary of the Eastern Branch of the Elizabeth River located directly west of I-64.





Land use in this 1,121 acre (1.9 square miles) watershed is dominated by commercial and institutional uses including a regional mall, several hotels and motels, a large office park and medical center. There are a few small pockets of residential uses as well as a large cemetery. The relatively high permeability of the cemetery is offset by the large Interstate Highway interchange also located in the watershed. Even though the watershed has very little light industry, the large number of streets and highways yields a high acreage number for light industry. Acreage totals for each land use category and estimated annual NPS loadings are presented in Table 9.

NPS Pollution Impacts

As with the other typical watersheds, nonpoint source loadings of TSS, lead, and zinc are greater than from the one MGD STP. In comparison to the other typical watersheds, estimated per acre loadings for this watershed are quite high for all parameters.

In terms of impact on critical habitat, runoff from this area will have a much greater impact than will the other Elizabeth River typical watersheds. This is due simply to the fact that the part of the Elizabeth River Eastern Branch to which this area drains has substantial wetland areas. It is likely that other critical habitat features are also present due to the wetland environment. Nonpoint Source impacts on these habitats as described earlier in Chapter II may be expected.

Recommended NPS Management Strategies

The following strategies are recommended for this typical watershed.

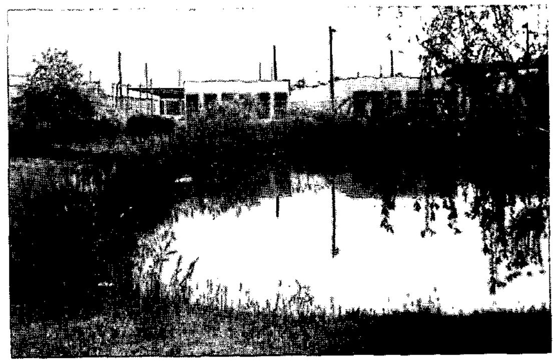
- In the portions of the watershed still containing developable land, encourage use of wet detention basins with extended detention devices or small dry extended detention ponds as the preferred NPS control options.

- Investigate the retrofitting the I-264/44 interchange with wet or dry detention ponds.

- Establish educational programs through local civic associations promoting residential "good housekeeping" practices to reduce NPS pollution. These practices include recycling; proper storage, use and disposal of hazardous materials; proper fertilizer use; proper vehicle maintenance; low maintenance landscaping to prevent erosion; and proper disposal of pet wastes.

TYPICAL WATERSHED - LIGHT INDUSTRY (AIRPORT INDUSTRIAL PARK)

Description



This 545 acre basin contains the Virginia Beach Airport Industrial Park. Basin boundaries are Shore Drive on the north; the Norfolk and Western rail line on the south; Diamond Springs Road on the east; and Norfolk International Airport on the west. This basin drains from south to north into an unnamed creek which flows into Lake Whitehurst and Little Creek Reservoir, two Norfolk water supply lakes. There are several detention ponds within this basin which were probably created as borrow pits, but now provide some flooding and NPS pollutant control.

The Airport Industrial Park, which covers most of this basin, is nearly built-out with a mixture of light industrial and office uses. Some vacant land and a small amount of low density residential use exist in the southern portion of the basin. Land use and estimated NPS loading data for this basin are shown in Table 10.

NPS Pollutant Impacts

With the exception of TSS and fecal coliform, estimated average per acre NPS pollutant loads for this basin are high. This can be explained by increased runoff rates resulting from the high degree of imperviousness associated with this mix of land uses. The types of activities associated with these land uses may also be a factor. The elevated loadings for lead and zinc are most likely due to the heavy motor vehicle traffic generated by commercial and industrial uses.

Despite the small size of this basin, estimated loadings for lead and zinc greatly exceed those that can be expected from a one MGD STP. For the other pollutant parameters, absolute estimated loadings are small in comparison to the hypothetical STP loadings, but per acre averages indicate that a basin of this type has a high potential for generating NPS pollution.

Recommended NPS Management Strategies

The following recommendations should be considered in highly developed drainage basins with predominantly light industrial land use.

- Give preference to the following structural controls in any new development: wet detention basins with extended detention devices, the use of porous pavement for parking lots and other low traffic volume areas, and rooftop detention and disposal facilities.

- Where feasible, incorporate in-line storage facilities, flow regulators and treatment facilities (including oil and grease separators) into new or existing stormwater conveyance systems. Encourage the owners of privately owned and maintained drainage facilities to do the same.

- Increase the frequency of street and parking lot sweeping. If possible, use vacuum sweepers.

- Retrofit existing detention basins with extended detention devices.

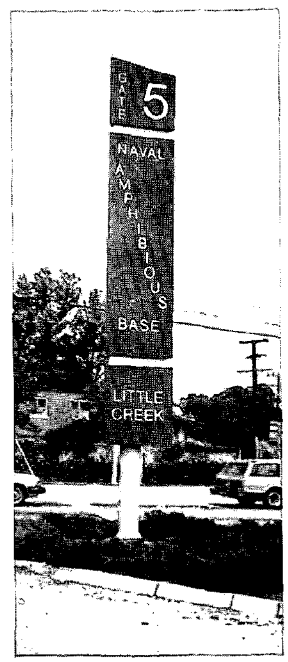
- Implement an educational program encouraging managers of industrial and commercial establishments to implement policies which might achieve a variety of objectives including NPS pollutant control. This program might address proper outside material storage, recycling of solid and hazardous wastes, compliance with hazardous material and underground storage tank regulations, low maintenance landscaping, and car and van pooling.

- Improve inspection and maintenance of public BMP structures and perhaps require owners of private facilities to do the same.

- Establish low-maintenance vegetative buffers along drainage ditches and the plant wetland grasses in detention basins.

TYPICAL WATERSHED - MILITARY (LITTLE CREEK)

Description



Nearly all of this 2,386 acre (3.7 square mile) basin is occupied by the Little Creek Naval Amphibious Base. This basin comprises about 15% of the entire Little Creek watershed. Its boundaries are the Chesapeake Bay on the north; Shore Drive on the south and west; and Lake Bradford and Chubb Lake on the east. Drainage in this basin is to Little Creek to the west, and to a series of seven small lakes, including Lake Bradford and Chubb Lake, to the east, and the Chesapeake Bay to the north.

Overall land use on the Naval Amphibious Base is of relatively low density. Nearly 50% of the land area is classified as either open or undeveloped and includes dunes, beaches, wooded areas, a golf course and playing fields. The developed areas of the base contain a mix of commercial/institutional, industrial and residential facilities. The industrial uses primarily include the docking, maintenance, repair and training facilities associated with the base's fleet of amphibious assault craft. A private shipyard, a small railyard and the HRSD Chesapeake-Elizabeth Sewage Treatment Plant, all located along Shore Drive, are the only non-military uses within this basin. Land use and estimated NPS loading data for this basin are shown in Table 11.

NPS Pollutant Impacts

Given the large amount of open and undeveloped land in the basin as a whole, estimated per acre average loadings for each of NPS pollutant parameters are low to moderate. Despite the low basinwide loadings, Little Creek Harbor suffers from severe water quality degradation. High nutrient levels, depleted DO and high fecal coliform counts have been recorded.[28] Due to high fecal coliform counts, shellfish areas within Little Creek have been condemned since 1935. These water quality problems can be partially attributed to the Creek's limited ability to assimilate pollutants. They may also be due to significant NPS loadings generated by industrial uses in the vicinity of docking facilities, and, perhaps more importantly, to the operation and maintenance of military, commercial and recreational vessels using these facilities. NPS loading rates were not developed for marine vessels and marinas due to their high degree of variability. Thus, these sources are not accounted for in the basinwide loading estimates. No information is available on NPS water quality impacts in the lakes draining the eastern portion of the base.

Even with the large amount of open and undeveloped land and the small degree of imperviousness in this basin, estimated TSS, lead and zinc loadings are still many times greater than those that can be expected from a one MGD STP. Estimated NPS loadings for BOD, total phosphorus and total nitrogen are significantly lower than those from the hypothetical STP.

Recommended NPS Management Strategies

The most effective BMPs for this basin would be those directed towards the operation and maintenance of military, commercial and recreational vessels using Little Creek Harbor. A description and analysis of such BMPs is beyond the scope of this study. The reader is referred to the <u>Coastal Marinas Assessment Handbook</u>, developed by EPA Region IV, for further information.

To address NPS problems occurring on this or other military bases, consideration should be given to developing a watershed management plan. Because nearly the entire watershed is under the control of one landowner (the U.S. Navy), there is more of an opportunity for identifying and devoting sufficient attention to resolving basin-specific NPS problems. The following strategies should be considered for inclusion in a watershed management plan for a military base.

- Enforce good housekeeping practices such as recycling of solid and hazardous wastes; proper storage, use and disposal of hazardous materials; proper fertilizer use; proper vehicle maintenance; low maintenance landscaping to prevent erosion; proper outside material storage; and compliance with hazardous materials and wastes, underground storage tank and stormwater permitting regulations.

- Give preference to the following structural controls in any new development: wet detention basins with extended detention devices, the use of porous pavement for parking lots and other low traffic volume areas, and rooftop detention and disposal facilities.

- Improve inspection and maintenance of BMP structures.

- Where feasible in industrial areas, incorporate in-line storage facilities, flow regulators and treatment facilities (including oil and grease separators) into new or existing stormwater conveyance systems.

- Increase the frequency of street and parking lot sweeping in areas of the base with heavy motor vehicle traffic. If possible, use vacuum sweepers.

- Establish low-maintenance vegetative buffers along drainage ditches and around any water bodies receiving runoff.

TYPICAL WATERSHED - DOWNTOWN/URBAN COMMERCIAL (NORFOLK CENTRAL BUSINESS DISTRICT)

Description

This 410 acre watershed includes the downtown Norfolk waterfront commercial and financial district including the Waterside area. The watershed is generally bounded on the west by the Main Stem of the Elizabeth River; Brambleton Avenue on the north; St. Paul Boulevard to the Berkley Bridge on the east; and the Eastern Branch of the Elizabeth River on the south. The major stormwater outfall points discharge to the Main Stem and Eastern Branch of the Elizabeth River.

Land use in the watershed is typical of a thriving urban downtown financial a nd commercial center. Numerous high-rise office buildings dominate the skyline. Marinas, hotel/convention centers and a coliseum are also present. Large grade level parking lots are found throughout the watershed and add to the impermeable nature of the land surface. Land use data and estimated NPS source loadings are presented in Table 12.

NPS Pollution Impacts

Except for TSS, estimated per acre pollutant loadings from this area are high compared to the other areas. The primary reason for the higher per acre loadings is due to the very high amount of impermeable cover of a typical downtown area. Highly impervious areas result in substantially more stormwater runoff than permeable areas. Consequently, higher volumes of pollutants on the land are transported to receiving waters.

Comparison of runoff parameters from this watershed to a one MGD STP indicate that the estimated annual NPS loadings for lead and zinc are greater than they are from the STP.

The area of the Elizabeth River to which this area drains is almost entirely bulkheaded and has very little if any tidal wetlands or other critical habitat areas. Nonpoint loading impacts on benthic conditions and finfish transitting the area could be present.

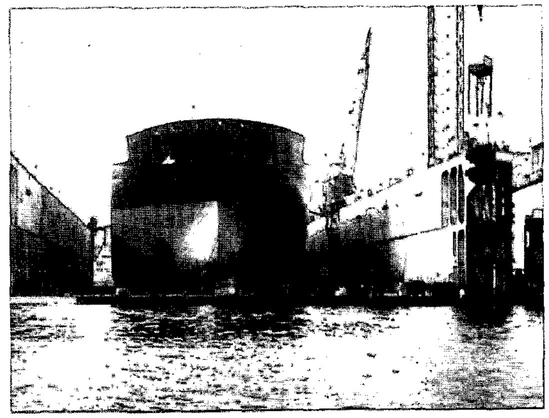
Recommended NPS Management Strategies

Because of limited homeownership, an information and education program regarding use and disposal of materials and substances impacting water quality is likely to have little impact. The following strategies are recommended for this type of basin.

- Incorporate permeable areas, filter strip plantings, and porous pavement into development plans wherever possible.
- Increase the frequency of street and parking lot sweeping in areas with heavy motor vehicle traffic. If possible, use vacuum sweepers.
- Where feasible, incorporate in-line storage facilities, flow regulators and treatment facilities (including oil and grease separators) into new or existing stormwater conveyance systems.
- Improve inspection and maintenance of BMP structures.

TYPICAL WATERSHED - HEAVY INDUSTRY (NORSHIPCO AREA)

Description



This 1,215 acre (1.9 square mile) watershed includes the heavily industrialized eastern shore of the lower Southern Branch of the Elizabeth River. The watershed is generally bounded by the Elizabeth River on the west; the Eastern Branch of the Elizabeth River on the north; State Street, Bainbridge Boulevard, B Street and Stewart Avenue on the east; and on the south by Ohio Street, Bainbridge Boulevard and Barnes Road.

Land use in the watershed is principally heavy industry. Two major ship repair facilities (NORSHIPCO and Metro Machine)are located at the upper end of the watershed. Petroleum and other liquid storage tank farms front on much of the remaining waterfront in the watershed. Interior areas include some high density single family residential neighborhoods. Land use acreage totals and estimated annual NPS loads are presented in Table 13.

NPS Pollution Impacts

With the exception of lead and zinc, per acre loadings of the pollutant parameters are less than from most of the other typical watersheds. Parameters not studied in this report may be of more significance to instream water quality and impact on living resources (TBT, PNAHs, and other metals and toxics). However, the shoreline of this area is heavily bulkheaded and has little in the way of tidal wetlands remaining. The most significant impact of runoff to living resources would be to benthic life and finfish transitting the area.

Recommended NPS Management Strategies

This watershed is so intensely developed with heavy industry that "conventional BMPs" will have little applicability. Instead, an environmental impact site audit of each industry in this watershed is recommended. The Chesapeake Bay Preservation Act authorizes localities to use their police powers for water quality protection. Consequently, working with industry management and Virginia State Water Control Board staff, City staff or their representatives should conduct extensive site visits and determine what constitute the controllable nonpoint source problems. It should be noted that the VSWCB is currently working on a special project to determine specific BMPs for shipyards. These BMPs are being incorporated into the NPDES Permits for these facilities. Together with industry management and the VSWCB staff, a control program and implementation schedule should be developed and agreed to.

CHAPTER VI

STORMWATER MANAGEMENT STRATEGY FOR SOUTHEASTERN VIRGINIA

Thus far, this report has attempted to describe the NPS pollution problem as it affects the water bodies in Southeastern Virginia's developed and developing areas. It has also summarized state and federal regulatory measures being developed to address this problem and has recommended basin-specific control strategies for typical types and mixes of land uses. The purpose of this chapter is to present a regional stormwater management strategy which will assist local governments in developing effective stormwater management programs that not only satisfy state and federal requirements, but also take full advantage of the authority granted to local governments under the Virginia Constitution and specific legislation to manage urban runoff.

The regional stormwater management strategy is intended to update and refine the urban NPS control recommendations of the Nonpoint Source Control Program for the Hampton Roads Area (presented in the 1983 update of the Hampton Roads Water Quality Management Plan). It also incorporates those urban NPS control recommendations included in the draft Virginia Nonpoint Source Pollution Control Program that are most suited to local government implementation in Southeastern Virginia.

The regional stormwater management strategy contains NPS control measures which are required by or are consistent with regulations developed to implement the 1987 Water Quality Act stormwater permitting provisions, and the 1988 Chesapeake Bay Preservation Act. Chesapeake, Norfolk, Portsmouth and Virginia Beach will be subject to both sets of regulations; Isle of Wight County and Suffolk to the CBPA regulations only; and Franklin a nd Southampton County will not be subject, at this time, to either set of regulations. Even if a locality is not required under law to comply with one or both sets of regulations, consideration should still be given to implementing control measures specific to these regulations in order to address local water quality concerns and to support regional water quality improvement efforts. The CBPA grants authority to all Virginia localities to exercise their police and zoning powers to protect the quality of state waters. Also, in the case of the stormwater permitting regulations, smaller localities not covered by the regulations currently proposed for large and medium municipalities may be subject to similar WQA-mandated regulations which the EPA must develop by 1992 (see Chapter I). These localities may therefore want to begin a stormwater management planning process in anticipation of these regulations.

Another reason for smaller localities to consider a stormwater management program is that, under federal law, a stormwater conveyance receiving illicit, non-stormwater discharges no longer meets the definition of a municipal separate storm sewer and may require an NPDES permit as a point source. If such a conveyance requires but is without a permit, the municipality operating the conveyance is in violation of the WQA, even if the illicit discharge is not generated by the municipality itself. A municipality in this situation may find itself subject to state or EPA enforcement proceedings, or to a citizen lawsuit brought under Section 505 of the WQA. In order to protect itself from such an occurrence, a locality not yet subject to federal stormwater permitting regulations may want to develop a stormwater management program which, at the very least, identifies and controls non-stormwater discharges entering its storm sewer systems.

It is recommended that the following stormwater management strategy be implemented by local governments. It is unlikely that every Southeastern Virginia locality will have the institutional flexibility to implement each of the control measures comprising this strategy. It is believed, however, that this strategy will provide direction to local governments in developing programs that identify local NPS problems, and include locally appropriate control measures and implementation priorities.

The regional stormwater management strategy is divided into four categories: stormwater impact monitoring, institutional initiatives, non-structural controls, and structural controls. Each of the NPS control measures included in these categories was selected with regard to its cost-effectiveness; its feasibility given local administrative and legislative capabilities as well as local physical constraints and opportunities; and its ability to achieve compliance with the EPA stormwater permitting regulations and the Chesapeake Bay Preservation Act.

STORMWATER IMPACT MONITORING

The identification and definition of NPS problems is the first step in the development of any stormwater management program. Local governments might either develop their own stormwater impact monitoring programs or participate in a regional program that accomplishes the same objectives. It is recommended that a stormwater impact monitoring program include the following activities.

- Implement the stormwater impact monitoring requirements of the proposed EPA stormwater permitting regulations (see Appendix A). These regulations describe and provide implementation guidelines for the following activities:
  - A source identification program which locates major outfalls; delineates drainage basins and determines land uses, natural features

and activities within each drainage basin that may affect the quantity and quality of runoff.

- A discharge characterization program which would screen for illicit, non-stormwater discharges (including those from sanitary sewers); conduct representative sampling to monitor the variation in NPS pollutants over time; and estimate pollutant loadings and concentrations.

INSTITUTIONAL INITIATIVES

Most local stormwater management programs in Southeastern Virginia will be required to incorporate initiatives mandated by the proposed CBPA and/or the EPA stormwater permitting regulations. These regulations are described in detail in Appendices A and B. Local programs will also include institutional initiatives that may support and reinforce state and federal requirements, but which are not mandatory. These initiatives are based on local policy decisions which take into consideration a locality's unique NPS problems and the availability of resources to solve them. The following briefly summarizes the institutional initiatives that are explicitly required under the proposed CBPA and stormwater permitting regulations. Also listed are recommendations for other initiatives that are not required, but should be integral components of any stormwater management program. Though not mandatory, these initiatives may be designed to ensure that a locality complies with state and federal regulatory programs.

Required Initiatives

- In accordance with the regulations developed under the Chesapeake Bay Preservation Act, identify environmentally sensitive areas which, if improperly developed, would lead to significant water quality degradation from NPS pollution. Incorporate CBPA criteria for protecting these areas into local comprehensive plans and land use control ordinances.

- Pursuant to the EPA stormwater permitting guidelines, implement a program that requires private and federal industrial facilities to provide certification that their industrial runoff has been tested for non-stormwater discharges and/or is in compliance with NPDES permits.

- Based on the results of the discharge characterization program described in the stormwater impact monitoring section, ensure that all illicit, non-stormwater discharges are either removed or are covered by a separate NPDES permit.

Recommended Initiatives

- In accordance with enabling legislation passed by the 1989 Virginia General Assembly, establish local stormwater management ordinances which require the submission and approval of site-specific stormwater management plans before certain development activities are approved. The recently adopted Virginia Beach Stormwater Management Ordinance provides a good example. In accordance with specific guidelines contained in these ordinances, these plans could be required to show compliance with local NPS controls developed under the CBPA and the stormwater permitting process, and with any additional controls instituted by a locality.

- In lieu of a stormwater management ordinance, use the authority granted by the CBPA to revise site plan review procedures to ensure compliance with local controls developed in response to the CBPA and EPA stormwater permitting regulations.

- Improve enforcement of Erosion and Sediment Control Ordinance and, where appropriate, exceed minimum guidelines and standards established by the state. It is suggested that erosion and sediment control practices be required for all construction activity affecting 2500 square feet or more.

- BMPs should be required in all new development subject to the requirements of the Erosion and Sediment Control Ordinance.

- As recommended by a resolution passed by the 1989 Virginia General Assembly (SJR 160), institute on-site sewage management districts in areas not served by sanitary sewers to monitor and control the performance of septic systems. These districts might be used to ensure that on-site sewage treatment systems located within designated preservation areas meet the inspection and pump-out requirements contained in the CBPA regulations.

- Adopt tree preservation ordinances to protect and maintain urban vegetation.

- Reduce the property tax assessment on land used for the purpose of controlling NPS pollution.

- Take advantage of state enabling legislation (Sec. 15.1-466(j)) which allows a locality to require a subdivider or developer to pay his pro rata share of the cost of providing off-site drainage facilities necessitated by his subdivision or development. A general drainage improvement program would be required before a locality could implement such a requirement.

NON-STRUCTURAL CONTROLS

Because they do not require maintenance and are generally more cost-effective, non-structural controls should be given preference over structural controls when comparable benefits will be achieved. Many of the non-structural NPS controls appropriate to Southeastern Virginia are contained in the proposed CBPA regulations (see Appendix B). These regulations contain guidelines for open space preservation, vegetation preservation and buffer zones, post-development runoff performance standards, land use restrictions in environmentally sensitive areas, and wetlands preservation and compensation. Localities should consider implementing the types of non-structural controls detailed in the CBPA regulations in areas outside of the identified Preservation Areas and outside of the Chesapeake Bay watershed. Other recommended non-structural controls include the following:

- Conduct an annual or semi-annual inspection of the operational effectiveness and integrity of publicly maintained structural BMPs. Encourage or require the owners of privately owned BMPs to do the same. (Local authority to require proper maintenance of privately owned BMPs appears to granted under the CBPA, although specific enabling legislation may be necessary.)

- Encourage the development of regional design and performance criteria for structural BMPs. These criteria would address such issues as the proper size and geometry of a BMP under different conditions; how vegetation can be effectively used to promote biological removal; how optimum detention or draining times can be achieved; and other means for achieving high pollutant removal efficiency.

- Establish educational programs which encourage residents and businesses to follow "good housekeeping practices" to reduce NPS pollution. Practices applicable to residents include recycling, especially of used oil; litter control; proper storage, use and disposal of hazardous materials; proper fertilizer use; low maintenance landscaping to prevent erosion; proper disposal of pet wastes; and proper vehicle maintenance. Practices applicable to businesses include proper outside material storage; recycling of solid and hazardous wastes; compliance with hazardous material, stormwater permitting and underground storage tank regulations; and car and van pooling.

- In areas with large amounts of impervious surface (industrial and commercial areas), increase the frequency of vacuum street sweeping.

STRUCTURAL CONTROLS

This section recommends structural BMPs for both developed and developing areas in Southeastern Virginia. These recommendations are based on the NPS control evaluation in Chapter III and on other studies which have evaluated the effectiveness of structural controls in Southeastern Virginia and elsewhere. Infiltration devices are generally not recommended in Southeastern Virginia due to high water tables, inadequate soil permeability and high maintenance requirements.

Developed Areas

- Where additional water quality benefits can be achieved and where economically and technically feasible, retrofit existing wet detention basins with extended detention devices.

- Evaluate opportunities for incorporating pollution control devices (such as storage facilities, flow regulators and treatment facilities) into local stormwater conveyance systems.

Developing Areas

- Where sufficient land is available, implement wet detention basins as the preferred BMP. Maximize the efficiency of these basins by using extended detention devices, retaining buffer zones around the basin and planting appropriate aquatic vegetation.

- Encourage the use of pervious pavement in low volume traffic areas (parking lots, driveways and so forth).

- Require activity-specific structural BMPs for all new development involving outside materials storage and/or the use or storage of hazardous materials and waste.

END NOTES

[1]U.S. Environmental Protection Agency Nonpoint Source Task Force. October 25, 1984. "Final U. S. Environmental Protection Agency Nonpoint Source Strategy".

[2]Code of Federal Regulations. 1985. Sec 140 (4).

[3]Id. sec. 130.8 (4).

[4]Sec. 62, Federal Water Quality Act of 1965.

[5]Sec. 201, Federal Water Pollution Contro; Act Amendments of 1972.

[6]Sec. 502 (14), Federal Water Pollution Control Act Amendments of 1972.

[7]Sec. 405 (p) (2), Water Quality Act of 1987.

[8]Id. sec. 405 (p) (3) (B).

[9]Id. sec. 405 (p) (4) (A).

[10]Id. sec. 405 (p) (4) (B).

[11]The State Water Control Law defines "state waters" as "all water, on the surface and under the ground, wholly or partially within or bordering the State or within its jurisdictions.....".

[12]State Water Control Board, Virginia Code Annotated. 1982 and Supp. 1986. Sec. 62.1-44.2.

[13]State Water Control Board, Best Management Practices Handbook: Management, (Richmond, Virginia: SWCB, 1979), p. I-2.

[14]Virginia Division of Soil and Water Conservation, Virginia Nonpoint Source Pollution Management Plan, (Richmond, Virginia: DSWC, 1989), p. 5-2.

[15]Commonwealth of Virginia, Title 10.1, Chapter 5, pp. 99-100, Code of Virginia, 1950, as amended.

[16]Chesapeake Bay Foundation, Conserving Our Wetland Resources: Avenues for Citizen Participation, (Richmond, Virginia: CBF, 1987), p. 12.

[17]State Water Control Board, Public, Leased and Condemned Shellfish-Growing Areas in the Commonwealth of Virginia, (Richmond, Virginia: SWCB), 1980), p. A-1.

[18]U.S. Environmental Protection Agency, 44 Federal Register 30033, May 23, 1979.

[19]State Water Control Board, Best Management Practices Handbook: Urban, (Richmond, Virginia: SWCB, 1979), p. III-2.

[20]Virginia Water Resources Research Center, Effects of Nonpoint Pollution on Benthic Invertebrates in the Lynnhaven River System, Blacksburg, Virginia: VWRRC, 1979), p. 8.

[21]Commonwealth of Virginia, Title 10.1, Chapter 5, pp. 99-100, Code of Virginia, 1950, as amended.

[22]40 CFR, Parts 122, 123, 124, and 504, "National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges; Proposed Rule," Federal Register 49416, December 7, 1988, p. 49459.

[23]Southeastern Virginia Planning District Commission, Hampton Roads Water Quality Management Plan: Future Land Use Element (Task 7.6), (Norfolk, Va: SVPDC, 1978).

[24]Large development proposals have been made for the Lawnes Creek basin. Although rezonings for these projects were recently denied, there is a possibility that this area will eventually succumb to development pressures.

[25]The 1980 population estimates for the Lynnhaven River basin was based on a disaggregation of 1980 census tract data to the Transportation Zone (TZ) level by the SVPDC staff in 1987. Since TZ boundaries and drainage basin boundaries do not nesessarily correspond, it was necessary to split and assign portions of some TZs to drainage basins. For each TZ that required splitting, the percentage of the TZ assigned to each drainage basin was determined. These percentages were then used to proportion and allocate population totals in each TZ to drainage basins.

[26]Hampton Roads Water Quality Agency, Hampton Roads Water Quality Management Plan: Public Hearing Draft (Virginia Beach, Virginia: HRWQA, 1978), p. 64.

[27]Virginia Institute of Marine Science, Water Quality Trends in the Lynnhaven Bay (Gloucester Point, Virginia: VIMS, 1982).

[28]Hampton Roads Water Quality Management Study, Hampton Roads Water Quality Management Plan: Appendix 9 - Ecoystems Survey, (Virginia Beach, Virginia: HRWQA, 1976), p. 54.

BIBLIOGRAPHY

Amos, William H. and Stephen H. Amos. The Audubon Society Nature Guide: Atlantic and Gulf Coasts. New York, New York: Alfred A. Knopf, 1985.

Bradshaw, Julie G. and Albert Y. Kuo. Salinity Distribution in the James Estuary. Gloucester Point, Virginia: Virginia Institute of Marine Science, 1987.

Chesapeake Bay Foundation. Conserving Our Wetland Resources: Avenues for Citizen Participation. Richmond, Virginia: CBF, 1987.

Chesapeake Bay Local Assistance Board. Chesapeake Bay Preservation Area Designation and Management Regulations (Proposed Regulation: VR 173-02-00). Richmond, Virginia: CBLAB, 1989.

Chesapeake Bay Local Government Advisory Committee. Recommendations of the Nonpoint Source Control Subcommittee to the Local Government Advisory Committee Concerning Nonpoint Source Control Needs: A Draft White Paper. LGAC, 1988.

Chesapeake Bay Program, Chesapeake Bay Stock Assessment Committee. Draft Chesapeake Bay Stock Assessment Plan. 1988.

City of Virginia Beach. The Comprehensive Plan. Virginia Beach, Virginia: The City, 1985.

Cline, Stephen. "Stencil the Town Fishy" in Sierra. March, 1989.

Commonwealth of Virginia. Report of the Joint Subcommittee Studying Pollution from Untreated Sewage Discharges and Failing Septic Tanks. Richmond, Virginia: The Commonwealth, 1989.

__________. Title 10.1, Chapter 5, Article 4, Code of Virginia, 1950, as amended.

__________. Title 62.1, Chapter 3.1, Code of Virginia, 1950, amended.

Cox, William E. and Lorraine M. Herson. Control of Nonpoint Source Pollution in Virginia: An Assessment of the Local Role. Blacksburg, Virginia: Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, 1987.

Dauer, Daniel M. et al. Effects of Non-Point Pollution on Benthic Invertebrates in the Lynnhaven River System. Blacksburg, Virginia: Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, 1979.

Erkenbrecher, Carl W. Jr. Sediment Bacteria as a Water Quality Indicator in the Lynnhaven Estuary. Blacksburg, Virginia: Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, 1980.

Geske, Bob. "Crabbers Fight Cold for Bay's Winter Harvest" in The Virginian Pilot. January 31, 1988.

Gilbert Associates, Inc. Supplemental Report: Northwest River Water Supply Project. Reading, Pennsylvania: Gilbert Associates, Inc., 1969.

Gilley, Susan, ed. Virginia's Wildlife. Richmond, Virginia: Virginia Commission of Game and Inland Fisheries, 1984.

Greenfield, Richard R. "Controlling Nonpoint Sources of Pollution - The Federal Legal Framework and the Alternatives of Nonfederal Action" in Perspectives on Nonpoint Source Pollution: Proceedings of a National Conference. Washington, D.C.: EPA, 1985.

Hampton Roads Water Quality Agency with the Southeastern Virginia Planning District Commission. Comprehensive Elizabeth River Water Quality Management Plan: Preliminary Management Recommendations. Norfolk, Virginia: HRWQA, 1986.

Hampton Roads Water Quality Agency. Hampton Roads Water Quality Management Plan. Appendix 5: Nonpoint Source Studies. Virginia Beach, Virginia: HRWQA, 1978.

____________. Hampton Roads Water Quality Management Plan, Appendix 7: Physical Features and Land Use Studies. Virginia Beach, Virginia: HRWQA, 1978.

____________. Hampton Roads Water Quality Management Plan, Appendix 9: Environmental Assessment. Virginia Beach, Virginia: HRWQA, 1978.

____________. Hampton Roads Water Quality Management Plan, Continuing Planning Process: Preliminary Nonpoint Source Control Plan and Management Practice Effectiveness and Cost Studies. Norfolk, Virginia: HRWQA, 1982.

____________. Hampton Roads Water Quality Management Plan, Continuing Planning Process: Lynnhaven and Northwest Rivers. Norfolk, Virginia: HRWQA, 1982.

Heaney James P. and Wayne C. Huber. "Nationwide Assessment of Urban Runoff Impact on Receiving Water Quality" in Water Resources Bulletin. Vol. 20, 1984, pp.35-42.

Henningson, Durham and Richardson. Environmental Impact Assessment, Preliminary Preliminary Report: Potable Water Supply Study for Southeastern Water Authority of Virginia. Norfolk, Virginia: Henningson, Durham and Richardson, 1974.

James R. Reed and Associates. Southeastern Expressway Project Anadromous Fish Study Final Report: Spring Sampling. Newport News, Virginia: James R. Reed and Associates, 1988

Koceisen, Carol. "Memorandum to Participants in National League of Cities Meeting with the U.S. Environmental Protection Agencies to Discuss Stormwater Issues". July 21, 1987.

Kuo, C.Y. et al. A Study of Infiltration Trenches. Blacksburg, Virginia: Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, 1989.

________________. Effectiveness of BMPs for Stormwater Management in Urbanized Watersheds. Blacksburg, Virginia: Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, 1988.

Kusler, Jon A. Our National Wetland Heritage: A Protection Guidebook. Washington, D.C.: Environmental Law Institute, 1983.

Library of Congress, Congressional Research Service, Environment and Natural Resources Policy Division. Nonpoint Pollution and the Areawide Waste Treatment Management Program Under the Federal Water Pollution Control Act: Summary of Hearings Before the Subcommittee on Oversight and Review, July 11, 12, 17 and 18, 1979. Washington, D.C.: U.S. Government Printing Office, 1980.

Lower James River Association. Lower James River Corridor Study. Richmond, Virginia: LJRA, 1988.

Migdalski, Edward C. and George S. Fichter. The Fresh and Salt Water Fishes of the World. New York, New York: Alfred A. Knopf, 1976.

Norman, Mitchell. "Lake of Many Faces" in Virginia Wildlife. April, 1984. pp. 33-35.

________________. Salinity and Fish Population Changes in Back Bay, 1959-1986. Richmond, Virginia: Virginia Department of Game and Inland Fisheries, undated.

________________. "What Happened to the Back Bay?" in Virginia Wildlife. August, 1988, pp. 22-30.

Norman, Mitchell D. and Ron Southwick. Back Bay: Report on Salinity and Water Clarity in 1986. Richmond, Virginia: Virginia Department of Game and Inland Fisheries, 1987.

__________________. Notes on the Species Composition, Relative Abundance and Distribution of the Fishes Collected in the Nottoway River Drainage in 1982 and 1984. Richmond, Virginia: Virginia Department of Game and Inland Fisheries, 1985.

__________________. Results of Back Bay Fish Population Sampling, 1985-86. Richmond, Virginia: Virginia Department of Game and Inland Fisheries, 1987.

__________________. Results of Back Bay Nutrient Sampling, April 1986 - March 1987. Richmond, Virginia: Virginia Department of Game and Inland Fisheries, 1987.

North Carolina State University, Water Quality Group. Nonpoint Source Pollutant Loading Factors and Related Parameters. Raleigh, North Carolina: N.C. State, 1987.

Old Dominion University, The Applied Marine Research Laboratory. The Evaluation of the Distribution of Toxicants/Mutagens in the Elizabeth River, Virginia in Relation to Land Use Activities. Norfolk, Virginia: ODU, 1988.

Orth, Dr. Robert. "Grasses Beneath the Bay" in Virginia Wildlife. August, 1987. pp. 28-31.

Public Law 92-217. "Federal Water Pollution Control Act Amendments of 1977".

Public Law 92-500. "Federal Water Pollution Control Act Amendments of 1972".

Public Law 100-4. "Water Quality Act of 1987".

Robblee, M.A. "Community Structure and Production in a Marsh on the Southern Branch of the Elizabeth River, Virginia", Unpublished thesis, Old Dominion University, 1973.

Reed, James R. Jr. Stream Community Response to Road Construction Sediments. Blacksburg, Virginia: Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University, 1977.

Roy Mann Associates, Inc. A Management Plan for Back Bay. Boston, Massachusetts: Roy Mann and Associates, Inc., 1984.

Scott, J.B., C.R. Stewart and Q.J. Stober. "Effects of Urban Development in Kelsey Creek, Washington" in Transactions of the American Fisheries Society. 1986, pp. 555-567.

Sholar, Terry. "Nursery Areas in the Estuary" in Albemarle-Pamlico Advocate. July, 1988, pp. 3-4.

Southeastern Virginia Planning District Commission. Hampton Roads Economic Forecast. Chesapeake, Virginia: SVPDC, 1987.

________________. The Value of Wetlands: A Guide for Citizens. Chesapeake, Virginia: SVPDC, 1988.

________________. Watershed Management Plans: Cavalier Industrial Area and Greenbrier Planned Community. Norfolk, Virginia: SVPDC, 1985.

________________. The Waters of Southeastern Virginia, Volume II: A Regional Waterways Guide. Chesapeake, Virginia: SVPDC, 1988.

State Water Control Board. Chowan River Basin 208 Project. Richmond, Virginia: Malcolm Pirnie Inc., 1983.

________________. Public, Leased, and Condemned Shellfish-Growing Areas in the Commonwealth of Virginia. Richmond, Virginia: SWCB, 1980.

State Water Control Board, Tidewater Regional Office. State Water Control Board's Role in Virginia's Shellfish Sanitation Control Program. Virginia Beach, Virginia: SWCB, 1980.

Stroup, E.D. and R.J. Lynn. Atlas of Salinity and Temperature Distributions in Chesapeake Bay, 1952-1961, and Seasonal Averages, 1949-1961: Graphical Summary Report 2. Baltimore, Maryland: Chesapeake Bay Institute, Johns Hopkins University, 1963.

Thompson, Paul and Robert W. Adler. Comments of the Natural Resources Defense Council, Inc. on Virginia's Proposed Nonpoint Source Pollution Management Plan to Fulfill the Requirements of CWA Section 319. Washington, D.C.: NRDC, 1988.

Tiner, Ralph W. Jr. Mid-Atlantic Wetlands: A Disappearing Natural Treasure. Newton Corner, Massachusetts: EPA, 1987.

URS Corporation. Summary of the NPDES Permit Application Regulations for Stormwater Discharges. Virginia Beach, Virginia: URS, 1989.

_______________. Surface Water Management: the Utility Approach. URS, 1987.

U.S. Army Corps of Engineers. Chesapeake Bay Low Freshwater Inflow Study, Appendix E - Biota. Baltimore, Maryland: COE, 1984.

_______________. Final Environmental Impact Statement: Hampton Roads Energy Company's Portsmouth Refinery and Terminal, Portsmouth, Virginia (Permit Action). Norfolk, Virginia: COE, 1977.

U.S. Environmental Protection Agency. Chesapeake Bay: A Profile of Environmental Change. Philadelphia, Pennsylvania: EPA, 1983.

_______________. Chesapeake Bay Program Technical Studies: A Synthesis. Washington, D.C.: EPA, 1982.

_______________. Proceedings: Urban Stormwater Management Seminars. Washington, D.C.: EPA, 1975.

_______________. Code of Federal Regulations, Title 40, Part 122. "National Pollution Discharge Elimination System Permit Regulations: Modification of Application Deadline and Testing Requirements for Storm Water Point Sources." Federal Register 9362, March 7, 1985.

_______________. 40 CFR, Part 122. "National Pollution Discharge Elimination System Permit Regulations; Storm Water Point Sources; Additional Information and Request for Comments." Federal Register 32548, August 12, 1985.

_______________. 40 CFR, Part 122. "National Pollution Discharge Elimination System Permit Regulations: Suspension of Existing Application Deadlines for Group I and Group II Storm Water Point Sources." Federal Register 39240, October 21, 1987.

_______________. 40 CFR, Part 122. "National Pollution Discharge Elimination System; Deletion of Existing Storm Water Discharge Permit Regulations and Permit Application Deadlines for Group I and Group II Storm Water Discharges." Federal Register 4157, February 12, 1988.

_______________. 40 CFR, Parts 122, 123, 124, and 504. "National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges; Proposed Rule." Federal Register 49416, December 7, 1988.

_______________. 40 CFR, Part 135. "Water Quality Planning and Management". Washington, D.C.: EPA, 1985.

U.S. Environmental Protection Agency, National Environmental Research Center. Impacts of Construction Activities in Wetlands of the United States. Washington, D.C.: EPA, 1976.

_______________. The Influence of Land Use on Stream Nutrient Levels. Washington, D.C.: EPA, 1976.

_______________. Urban Runoff Pollution Control Technology Review. Washington, D.C.: EPA, 1977.

_______________. Urban Stormwater Management and Technology: An Assessment. Washington, D.C.: EPA, 1974.

U.S. Environmental Protection Agency, Nonpoint Source Branch. Nonpoint Source Monitoring and Evaluation Guide (Draft). Washington, D.C.: EPA, 1988.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. EPA Handbook: Remedial Action at Waste Disposal Sites (Revised). Washington, D.C.: EPA, 1985.

U.S. Environmental Protection Agency, Office of Research and Monitoring. Water Pollution Aspects of Street Surface Contaminants. Washington, D.C.: EPA, 1972.

U.S. Environmental Protection Agency, Office of Public Awareness. A Guide to the Clean Water Act Amendments. Washington, D.C.: EPA, 1978.

U.S. Environmental Protection Agency, Office of Water. Nonpoint Source Guidance. Washington, D.C.: EPA, 1987.

U.S. Environmental Protection Agency, Office of Water, Enforcement and Permits. Development Plan for NPDES Storm Water Permits Program. Washington, D.C.: EPA, 1987.

_______________. Notice of Proposed Rulemaking (NPRM) for National Pollutant Discharge Elimination System (NPDES) Permit Application Requirements for Storm Water Discharges. Washington, D.C.: EPA, 1988.

U.S. Environmental Protection Agency, Office of Water, Regulation and Standards. Setting Priorities: The Key to Nonpoint Source Control. Washington, D.C.: EPA, 1987.

U.S. Environmental Protection Agency, Office of Water and Waste Management. Institutional Bases for Control of Nonpoint Source Pollution. Washington, D.C.: EPA, 1979.

U.S. Environmental Protection Agency, Office of Wetlands Protection. America's Wetlands: Our Link Between Land and Water. Washington, D.C.: EPA, undated.

U.S. Environmental Protection Agency, Region III, Annapolis Field Office. Distribution of Metals in Elizabeth River Sediments. Annapolis, Maryland: EPA, 1976.

_______________. Chesapeake Bay Nonpoint Source Programs. Annapolis, Maryland: EPA, 1988.

U.S. Environmental Protection Agency, Region IV. Coastal Marinas Assessment Handbook. Atlanta, Georgia: EPA, 1985.

U.S. Environmental Protection Agency, Water Planning Division. Results of the Nationwide Urban Runoff Program, 3 vols. Washington, D.C.: EPA, 1983.

_______________. Water Quality Management Planning for Urban Runoff. Washington, D.C.: EPA, 1974.

U.S. Fish and Wildlife Service, Region 5 and Annapolis Field Office. Atlas of National Wetlands Inventory Maps of Chesapeake Bay (Volume 1 - Coastal Plains Virginia, Western Shore). Newton Corner, Massachusetts: USFWS, 1986.

Virginia Beach Department of Public Works. Stormwater Management Plan. Virginia Beach, Virginia: The City, 1987.

Virginia Council on the Environment. Shoreline Management Options for Virginia Coastal Localities. Richmond, Virginia: VCOE, 1988.

Virginia Department of Conservation and Historic Resources, Division of Soil and Water Conservation. Implementation Effectiveness of the Virginia Erosion and Sediment Control Program. Richmond, Virginia: The State, 1988.

_______________. Virginia Erosion and Sediment Control Handbook. Richmond, Virginia: VDCHR, 1980.

_______________. Virginia Nonpoint Source Pollution Assessment Report. Richmond, Virginia: VDCHR, 1988.

_______________. Virginia Nonpoint Source Pollution Management Program. Richmond, Virginia: VDCHR, 1988 (revised, 1989).

Virginia Institute of Marine Science. Chesapeake Bay Research Initiatives at the Virginia Institute of Marine Science of the College of William and Mary. Gloucester Point, Virginia: VIMS, 1988.

______________. Shoreline Situation Report: Cities of Chesapeake, Norfolk, and Portsmouth. Gloucester Point Virginia: VIMS, 1976.

______________. Shoreline Situation Report: City of Suffolk. Gloucester Point Virginia: VIMS, 1978.

______________. Shoreline Situation Report: City of Virginia Beach. Gloucester Point Virginia: VIMS, 1978.

______________. Shoreline Situation Report: Isle of Wight County. Gloucester Point Virginia: VIMS, 1975.

______________. Tidal Marsh Inventory: City of Virginia Beach, Volume 1, North Landing River and Tributaries. Gloucester Point, Virginia: VIMS, 1976.

______________. Tidal Marsh Inventory: City of Norfolk. Gloucester Point, Virginia: VIMS, 1987.

______________. Tidal Marsh Inventory: City of Virginia Beach, Volume 2, Lynnhaven River, Lake Rudee and Their Tributaries. Gloucester Point, Virginia: VIMS, 1976.

______________. Tidal Marsh Inventory: Isle of Wight County. Gloucester Point, Virginia: VIMS, 1981.

______________. Tidal Marsh Inventory: Surry County. Gloucester Point, Virginia: VIMS, 1981.

Virginia Institute of Marine Science and Virginia Marine Resources Commission. Wetlands Guidelines. Gloucester Point, Virginia: VIMS, undated.

Virginia Polytechnic Institute and State University, Agricultural Engineering Department. The Effects and Control of Non-Point Pollution of Water Resources: As Applied in Virginia. Blacksburg, Virginia: VPI, 1977.

Virginia Water Control Board. Virginia Water Quality Assessment: 1986, 2 vols. Information Bulletin 565. Richmond, Virginia: VWCB, 1986.

______________. Best Management Practices Handbook: Management. Richmond, Virginia: VWCB, 1981.

______________. Best Management Practices Handbook: Urban. Richmond, Virginia: VWCB, 1979.

Wass, Marvin L. and Thomas D. Wright. Coastal Wetlands of Virginia: Interim Report. Gloucester Point, Virginia: Virginia Institute of Marine Science, 1969.

Water Resources Engineers and The Hydrologic Engineering Center, Army Corps of Engineers. Management of Urban Storm Runoff, American Society of Civil Engineers Water Resources Research Program, Technical Memorandum No. 24. New York, New York: ASCE, 1974.

Weibel, S.R., R.J. Anderson and R.L. Woodward. "Urban Land Runoff as a Factor in Stream Pollution" in Journal of the Water Pollution Control Federation. Vol. 36, 1964, pp. 915-924.

Weir, Sandra M. "Coastal Stormwater Management: Kill Devil Hills" in O. A. Communique. Spring, 1989, pp 1-2.

Woolpert and Associates, Inc. Coastal Zone Management Plan: City of Portsmouth Virginia. 1988.

Zaneski, Cyril T. "Pollution Shuts Down Major Clamming Area" in The Virginian-Pilot. November 6, 1988.

________________. "Sanitation Panel to Create Team to Search for Sewer Line Problems" in The Virginian-Pilot. March 29, 1989.

________________. "Utility Bills for Drainage May Fund City's Plan" in The Beacon. October 27, 1988, p. 5.

APPENDIX A

SUMMARY OF REGULATIONS PROPOSED BY THE EPA TO IMPLEMENT THE STORMWATER PERMITTING PROVISIONS OF THE 1987 WQA

INTRODUCTION

This appendix summarizes EPA's proposed permit application requirements for medium and large municipal separate storm sewer systems. It does not address the proposed permitting requirements for discharges associated with industrial activity, except in the case where a municipal system receives such discharges.

It should be emphasized that the regulations summarized below are proposals on which the EPA is seeking comment. Given the EPA's history in trying to develop final stormwater permitting regulations under the 1972 Clean Water Act, it is likely that the proposed regulations will undergo some change before the final regulations are promulgated. However, the strict promulgation deadlines established by the WQA for large municipal systems do not allow for a major revision of the proposed regulations. History would indicate that legal challenges will be brought against the EPA after the final rules are promulgated. This could eventually lead to a remand and further revision of the regulations.

PROPOSED STRATEGY FOR IMPLEMENTING THE PERMIT PROGRAM

The EPA's proposed permit application procedures for large and medium municipal separate storm sewer systems are structured to lead to the development of site-specific stormwater management programs which would consist of locally appropriate pollution control measures. Permit conditions based on information received in the permit applications would be developed to guide the implementation of the site-specific programs. EPA's proposed strategy is based on the recognition that municipal separate storm sewer systems in different parts of the country vary with respect to the nature of their discharges as well as to the impacts those discharges have on the quality of receiving waters. Therefore, the EPA felt that it was impractical to develop one standard set of control measures for all pollutants discharged from all municipal systems.

DEFINITION OF LARGE AND MEDIUM MUNICIPAL SEPARATE STORM SEWER SYSTEMS

The EPA proposes to define a "municipal separate storm sewer" as "any conveyance or system of conveyances that is owned or operated by a State or local government entity and is used for collecting and conveying storm water which is not part of a publicly owned treatment works".

The 1987 WQA mandates that large municipal separate storm sewer systems (those serving populations greater than 250,000) and medium municipal separate storm sewer systems (those serving populations between 100,000 and 250,000) be covered by NPDES permits. The WQA does not, however, provide a geographic and/or administrative basis for defining a "municipal system". In its proposed rules, the EPA indicates a preference for defining a municipal separate storm sewer system as one that is owned or operated by a single municipality, or "incorporated place", and meets the WQA population criteria for a large or medium municipal system. The EPA recognizes, however, that many municipal systems meeting this definition are associated with and usually, but not always, physically connected to municipal separate storm sewer systems that are owned and operated by entities other than the incorporated place. Such entities might include adjacent, smaller municipalities, or county agencies, state agencies, flood control districts or sewer districts which operate storm sewer systems within the boundaries of an incorporated place. In these situations, the EPA proposes that the Director of the NPDES program be given discretionary authority to adjust the scope and/or boundaries of large and medium municipal separate storm sewer systems to include discharges from associated municipal systems.

Although the EPA states its preference for the above approach, it has requested comments on the following additional options for defining municipal separate storm sewer systems:

- designating systems owned and operated by counties with the appropriate population as municipal systems;
- designating state highway systems as a single municipal system requiring separate permits;
- using the boundaries of an incorporated place with the appropriate population to define a single municipal system. Under this option, separate storm sewer systems serving an incorporated place that are owned and operated by public entities other than municipal owner/operator would be automatically included in the municipal system without discretionary approval from the Director of the NPDES program;
- same as above, but using county boundaries to define a single municipal system; and
- using the boundaries of Census-defined urbanized areas to define municipal systems.

SYSTEM-WIDE PERMIT APPLICATIONS

Section 402(p)(3)(B)(i) of the 1987 WQA provides that permits for discharges from municipal separate storm sewer systems may be issued on a system-wide or jurisdiction-wide basis. The EPA favors this approach over the submittal of individual permit applications for each outfall. The system-wide permitting process will give municipal dischargers the opportunity to develop system-wide stormwater management programs which target controls based on an evaluation of priorities. In addition, the EPA will encourage multiple municipal entities with stormwater management responsibilities within the same system to be co-applicants for a single system-wide permit. This approach will provide a basis for coordinated stormwater management planning and will spread, among the co-applicants, the burden of monitoring discharges, assessing water quality impacts, and developing and implementing controls. If this approach is undesirable, however, the EPA proposes that an individual municipal entity within a system be allowed to apply for a permit covering that portion of the storm sewer system for which they are responsible.

REQUIREMENT TO PROHIBIT NON-STORMWATER DISCHARGES

Section 402(p)(3)(B)(ii) of the 1987 WQA requires that permits issued for discharges from municipal separate storm sewers include a provision that "effectively prohibits" non-stormwater discharges into storm sewers. EPA's interpretation of this provision is that it is not meant to prohibit all discharges to municipal separate storm sewers that are not comprised entirely of stormwater. Rather, non-stormwater discharges to municipal systems may be allowed as long as they are covered by separate NPDES permits. The intent of this provision, according to EPA's interpretation, is to either remove or ensure NPDES permit coverage of illicit and untreated non-stormwater discharges to municipal storm sewers. To accomplish this, EPA's proposed permit application process would require municipal applicants to conduct a screening analysis and develop a site- specific management plan to identify and control improper disposal to their storm sewer systems.

RESPONSIBILITY FOR STORMWATER ASSOCIATED WITH INDUSTRIAL ACTIVITY THAT DISCHARGES TO MUNICIPAL SEPARATE STORM SEWERS

The EPA proposes to hold the operators of large and medium municipal separate storm sewer systems primarily responsible for applying for and obtaining NPDES permits covering not only system discharges, but stormwater discharges to the system as well. This approach would relieve those facilities which discharge stormwater associated with industrial activity to municipal separate storm sewers and meet certain conditions from having to obtain individual NPDES permits. The EPA proposes to define the term "associated with industrial activity" as "directly related to manufacturing, processing or raw material storage areas at an industrial plant." The proposed regulations supplement this definition by listing the types of facilities that would be defined as "industrial plants" and describing the types of areas within industrial plants that are directly related to industrial processes (see Section 122.26(b)(13)). The proposed definition of "associated with industrial activity" would not include "discharges associated with parking lots, and administrative and employee buildings."

To be exempt from having to obtain individual NPDES permits for their stormwater discharges, EPA proposes that industrial facilities meet the following conditions:

- The operator of an affected industrial facility must provide the operator of the municipal separate storm sewer a certification that the facility's stormwater discharge has been tested for the presence of non-stormwater discharges;

- The discharge from an industrial facility to a municipal storm sewer must be comprised entirely of stormwater;

- The discharge from an industrial facility to a municipal separate storm sewer must be in compliance with the management program established in the NPDES permit issued to the municipal operator; and

- The discharge from an industrial facility to a municipal separate storm sewer must not contain a hazardous substance in excess of the reporting quantities established under the WQA or the Comprehensive Environmental Response, Compensation, and Liability Act.

Under EPA's proposed permit application requirements, municipal operators would be required to identify the locations of facilities which discharge stormwater associated with industrial activity into their systems. They would also be required to incorporate measures into their stormwater management programs which would reduce, to the maximum extent practicable, pollutants in such discharges.

The EPA is also requesting comment on whether federal facilities which discharge stormwater associated with industrial activity into municipal separate storm sewers should be required to obtain individual permits.

SPECIFIC REQUIREMENTS OF THE PROPOSED PERMIT APPLICATION

The EPA proposes a two-part application process for discharges from large and medium municipal storm sewer systems. The intended purpose of Part 1 of the permit application is to provide a basis for identifying the sources of pollutants contained in stormwater discharges; to preliminarily identify discharges that may require individual permits; and to formulate a strategy for characterizing stormwater discharges. The general components of Part 1 of the permit application, as proposed by the EPA, include:

- General information regarding the permit applicants or co-applicants;

- A description of existing legal authority to control pollutants in stormwater discharges, and a plan to augment such authority if necessary;

- Source identification information including a description of the historic use of ordinances or other controls which limited the discharge of non-stormwater to municipal systems, and the locations of known municipal separate storm sewer system outfalls;

- Information characterizing the nature of system discharges including existing quantitative data, the results of a field screening analysis to detect illicit discharges and illegal dumping into the municipal system, the development of a representative sampling program, a proposed plan to characterize discharges by estimating pollutant loads and concentrations, and an identification of receiving waters with known water quality problems associated with stormwater discharges;

- A description of existing structural and non-structural controls to reduce the discharge of pollutants from municipal storm sewers.

Part 2 of the permit application is designed to supplement information provided in Part 1 and to guide applicants in the preparation of comprehensive stormwater management programs. The permit authority will use the information presented in Part 2 to develop site-specific permit conditions which will be applicable for a five year term. EPA proposes that the general components of Part 2 of the permit application be as follows:

- A demonstration that legal authority of the permit applicant satisfies the regulatory criteria;

- Information added to Part 1 of the permit application, if necessary, to assure that all major outfalls are identified;

- Characterization of discharges from the municipal system including results from the screening analysis to detect illicit discharges, representative sampling data, and estimates of pollutant loadings and concentrations in discharges;

- A proposed stormwater management program to control the discharge of pollutants to the maximum extent practicable;

- An assessment of the performance of proposed controls;

- A financial analysis estimating the cost of implementing the proposed management program and an identification of sources of revenues; and

- A description of the roles and responsibilities of co- applicants.

The EPA has structured Parts 1 and 2 of the proposed permit application requirements to address four key issues. These include (1) the viability of local institutional mechanisms for controlling pollutants in stormwater discharges, (2) an identification of the sources of pollutants in stormwater discharges, (3) a characterization of stormwater discharges, and (4) the development of stormwater management programs. Specific permit information requirements for these areas of concern and proposed guidelines for collecting this information are briefly discussed below.

THE VIABILITY OF LOCAL STORMWATER MANAGEMENT PROGRAMS

The EPA has identified, and incorporated into the proposed permit application requirements, three prerequisites for a viable stormwater management program. They are legal authority, adequate financial resources and adequate administrative capabilities. The EPA proposes that adequate legal authority be established through statutes, ordinances and/or contracts which authorize or enable the applicant to control pollutants in stormwater discharges, prohibit illicit discharges and control spills, require compliance with permit conditions, and carry out inspection and monitoring procedures.

The EPA has not proposed specific guidelines for determining the adequacy of financial resources and administrative capabilities. It does, however, request comments on these issues.

SOURCE IDENTIFICATION

The source identification requirements of the proposed permit application are designed to determine the major sources in each drainage basin which contribute pollutants to a municipal separate storm sewer system. To fulfill the source identification requirements of Part 1 of the application, the EPA proposes that the applicant provide an inventory of all known major outfalls, and a proposed program to identify the locations of any major outfalls that have not yet been inventoried. The EPA defines an outfall as a point where a municipal system discharges to the waters of the United States. The EPA proposes to define a "major" outfall as a discharge pipe which either has a diameter of more than 36 inches (or drains an area of 50 acres or more), or drains land zoned for industrial activities and has a diameter of more than 12 inches (or drains an area of 2 acres or more). Applicants would be required to identify major outfalls only, not the entire conveyance network of a municipal system.

The proposed Part 1 source identification requirements also include the delineation of drainage areas associated with known outfalls, a description of major land use classifications in each drainage area, ten year projections of population growth and development activities, a description of soils, and the location of industrial facilities, open dumps, landfills and RCRA hazardous waste facilities.

The source identification information required in Part 2 of the permit application will generally supplement the information reported in Part 1 by identifying all major outfalls.

CHARACTERIZATION OF DISCHARGES

As mentioned in the above description of the general components of Part 1 of the proposed permit application, the program to characterize discharges will consist of a screening analysis for illicit discharges, a representative sampling program, estimates of pollutant loadings and concentrations, and identification of receiving waters with known water quality impacts associated with stormwater discharges. The following summarizes the information requirements for each of these discharge characterization activities.

Screening Analysis for Illicit Discharges

The EPA proposes a two-phase screening analysis to be performed on major outfalls (as defined above) in municipal systems to detect illicit hookups and illegal dumping. The results of the first phase of this analysis, called the field screen, would be reported in Part 1 of the permit application and would be used to determine the priorities for the second phase of the analysis, the results of which would be included in Part 2 of the permit application. As proposed, the field screen would consist of visual observations of major outfalls during dry weather conditions. If any flow is observed, two grab samples would be collected during a 24 hour period (with a minimum period of four hours between samples). For these samples, a description of the color, odor, turbidity, the presence of oil sheen or surface scum, and any other relevant observations would be provided. In addition, the flow rate would be estimated, and field colormetric detection methods would be used to estimate pH, total chlorine, total copper, total phenol, total and hexavalent chromium, detergents (or surfactants) and free cyanide. Based on this initial screening, the applicant would submit a plan identifying major outfalls which deserve further study during the second phase of the analysis. The second phase of the screening analysis would require that both wet-weather and dry-weather samples be collected from the outfalls identified in the plan required in Part 1 of the application. These samples would be analyzed, using EPA approved techniques, for 20 pollutants which EPA has determined to be reliable indicators of illicit discharges and illegal dumping.

Representative Sampling Program

Because the pollutant concentrations in urban runoff can exhibit significant variation over time, the EPA is proposing that a monitoring plan be implemented as a permit condition and carried out during the term of the permit. In order to provide permit writers with the data necessary to develop site-specific monitoring requirements, all relevant existing data reported in Part 1 of the permit application would be considered. In addition, the EPA proposes that this information be verified and supplemented through sampling data collected by the applicant during representative storm events for between five and ten outfalls. The locations of these outfalls, a schedule for sampling and a description of the proposed sampling equipment would be required in Part 1 of the permit application. It is proposed that the selected outfalls be representative of the commercial, residential and industrial activities of the drainage area contributing to the system. For at least one outfall, the applicant would be required to collect stormwater samples from three representative storm events that occur at least one month apart. Under the proposed requirements, the sampling data would be analyzed for a wide range of pollutants designated by the EPA including toxics and hazardous materials. The results of this analysis would be reported in Part 2 of the permit application. The permitting authority would use the results of this sampling process along with the existing quantitative data reported in Part 1 of the permit application to develop the ongoing monitoring program for the municipal system.

Estimates of Pollutant Loadings and Concentrations

An assessment of water quality impacts associated with municipal stormwater discharges requires an analysis of pollutant loadings and concentrations in discharges. EPA proposes that the annual pollutant load and the mean event concentration of the cumulative discharge from all outfalls (including outfalls not classified as major outfalls) in a system be estimated to assess both short and long term water quality impacts. The characterization of instream pollutant concentrations based on estimated mean event pollutant concentrations in system discharges is important in assessing short term impacts. Possible short term impacts include periodic dissolved oxygen depletion, high bacteria levels, fish kills, acute effects of toxic pollutants, contact recreation impairments and loss of submerged macrophytes. An estimate of annual pollutant loading associated with stormwater discharges is essential in assessing long term impacts. Such impacts include lack of storage capacity in water bodies, lake eutrophication, destruction of benthic habitat, depressed dissolved oxygen due to oxidation of organics in bottom sediments, and the biological accumulation of toxics. A plan for estimating pollutant loads and concentrations would be included in Part 1 of the permit application while actual estimates would be reported in Part 2. The EPA proposes that estimates be developed for BOD, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, cadmium, copper, lead and zinc. The EPA would also require a description of the procedure used for arriving at these estimates.

Water Quality Impacts on Receiving Waters

Part 1 of the application would require that applicants list and briefly describe water quality impacts in water bodies which have been degraded as a result of discharges from municipal separate storm sewer systems. In compiling such a list and describing water quality impacts, the EPA proposes that the applicant use information from assessments required under sections 304, 305, 314, 319 and 320 of the WQA, and any available bottom sediment, fish tissue or biosurvey data.

THE DEVELOPMENT OF STORMWATER MANAGEMENT PROGRAMS

The NPDES permitting process for industrial process waste discharges and municipal sanitary sewers has relied on end-of- pipe, technology-based controls which can be uniformly applied to specific classes of discharges. The EPA has determined that this approach is inappropriate for municipal separate storm sewer discharges. Instead, the EPA is attempting to develop permit requirements that encourage the applicant to control pollutants in stormwater discharges through the development of flexible source-specific and site-specific stormwater management programs. The proposed permit application requirements are designed to give applicants the opportunity to develop locally appropriate control programs. Part 1 of the application would require a description of existing structural and non-structural control measures. Part 2 would require the applicant to identify additional measures that would be implemented during the term of the permit to control pollutants to the maximum extent practicable. These controls, if approved by the permitting authority, would then become permit conditions.

The proposed permitting regulations would require that Part 2 of the permit application describe stormwater management programs for four categories of stormwater discharges. These categories include (1) runoff from commercial and residential areas, (2) stormwater runoff from industrial areas, (3) runoff from construction sites, and (4) non-stormwater discharges. The proposed programs would not only describe control measures for each of these categories, but would propose implementation priorities as well. The EPA realizes that often discharges will be comprised of two or more of these categories. In these situations, control measures would need to be sufficient enough to reduce pollutants from multiple sources. The proposed permit application would require that the management programs for each category of discharge include consideration of certain types of control measures. A brief summary of the control measures that would have to be considered for each type of discharge is included below.

Runoff from Commercial and Residential Areas

A program to reduce pollutants in runoff from commercial and residential areas would be required to describe the following:

- Maintenance activities and a maintenance schedule for structural controls;

- Planning procedures including a comprehensive master plan to develop, implement and enforce controls to reduce the discharge of pollutants from areas of new development or significant redevelopment;

- Practices and procedures for operating and maintaining public streets, roads and highways to reduce the impact of runoff on receiving waters;

- Procedures to assure that flood management projects assess water quality impacts;

- A program to monitor pollutants from runoff from operating or closed municipal landfills or other treatment, storage or disposal facilities for municipal waste; and

- A program to reduce pollutants in stormwater discharges associated with the application of pesticides, herbicides and fertilizers.

Runoff from Industrial Areas

A program to monitor pollutants in runoff from industrial facilities that discharge to municipal separate storm sewers would be required to identify priorities and procedures for inspections, and establish and implement control measures.

Runoff from Construction Sites

A program to reduce pollutants in runoff from construction sites would be required to describe the following:

- Procedures for site planning which incorporate consideration of potential water quality impacts;

- Requirements for non-structural and structural best management practices;

- Procedures for identifying priorities for inspecting sites and enforcing control measures; and

- Appropriate educational and training measures for construction site operators.

Non-Stormwater Discharges

A program to detect and remove, or require NPDES permits for, illicit discharges and improper disposal into storm sewers would be required to describe the following:

- A program, including inspections, to implement and enforce ordinances, orders or similar means to prevent illicit discharges;

- Sampling requirements for the following constituents: fecal coliform, fecal streptococcus, VOC, surfactants, and residual chlorine;

- Other testing programs based on smoke testing, and testing with flourometric dyes;

- Procedures to prevent, contain, and respond to spills that may discharge to storm sewers;

- A program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from storm sewers;

- Description of educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oils and toxic materials; and

- Controls to limit infiltration of seepage from municipal sanitary sewers to municipal separate storm sewers.

In order to ensure that the required stormwater management programs are reducing pollutants in stormwater to the maximum extent practicable, as mandated by the 1987 WQA, the EPA is proposing that permittees submit annual status reports. These reports would be used by the permitting authority to aid in evaluating compliance with permit conditions and modifying permit conditions where necessary.

APPLICATION DEADLINES

The EPA proposes that, for large municipal systems, Part 1 of the permit application be submitted one year and Part 2 be submitted two years after publication of the final rule. The 1987 WQA requires that the final rule for large municipal systems be promulgated by February 4, 1989. The EPA was not be able to meet this deadline, however. As of this writing, the EPA does not expect the final rule to be promulgated until early 1990.

For medium municipal systems, the EPA proposes that Part 1 of the permit application be submitted by November 4, 1990 and that Part 2 be submitted be submitted by February 4, 1992. This assumes that the final regulations for medium municipal systems will be promulgated by February 4, 1990 as called for in the 1987 WQA.

APPENDIX B

DRAFT TEXT OF THE CHESAPEAKE BAY PRESERVATION ACT REGULATIONS

For information concerning Proposed Regulations, see information page.

Symbol Key

Roman type indicates existing text of regulations. *Italic type* indicates proposed new text. Language which has been stricken indicates proposed text for deletion.

CHESAPEAKE BAY LOCAL ASSISTANCE BOARD

Title of Regulation: **VR 173-02-00. Chesapeake Bay Preservation Area Designation and Management Regulations.**

Statutory Authority: §§ 10.1-2103 and 10.1-2107 of the Code of Virginia.

Public Hearing Dates:
May 3, 1989 - 7 p.m.
May 4, 1989 - 7 p.m.
May 8, 1989 - 7 p.m.
May 11, 1989 - 7 p.m.
May 16, 1989 - 7 p.m.
May 18, 1989 - 7 p.m.
May 24, 1989 - 7 p.m.
May 25, 1989 - 7 p.m.
May 30, 1989 - 7 p.m.
(See Calendar of Events section for additional information)

Summary:

This regulation is proposed by the Chesapeake Bay Local Assistance Board in accordance with provisions of §§ 10.1-2103 and 10.1-2107 of the Code of Virginia. The proposed regulation is divided into six parts dealing with (i) introductory matters, (ii) local government requirements, (iii) Chesapeake Bay Preservation Area criteria, (iv) land use and development performance criteria, (v) implementation, assistance, and determination of consistency, and (vi) enforcement.

Part I, "Introduction," establishes the purpose, authority, and applicability for the regulation and defines terms.

Part II, "Local Government Programs," sets forth the objectives of local programs that implement the regulations and lists the elements that must be included in local programs.

Part III, "Chesapeake Bay Preservation Area Designation Criteria," includes the first set of criteria required by the Code. These criteria describe the characteristics and objectives of Chesapeake Bay Preservation Areas and list the land types that must be included or considered for inclusion in preservation areas. Chesapeake Bay Preservation Areas are proposed to be subdivided into the more sensitive lands adjacent to the shoreline, called Resource Protection Areas, and less sensitive upland areas called Resource Management Areas.

Part IV, "Land Use and Development Performance Criteria," includes the second set of criteria required by the Code, called performance criteria. The performance criteria are subdivided into two groups: (i) general criteria that apply in all Chesapeake Bay Preservation Areas, and (ii) additional or more stringent criteria that apply only in the Resource Protection exceptions to the performance criteria.

Part V, "Implementation, Assistance, and Determination of Consistency," provides guidance in the orderly and timely development of local programs and criteria by which local program consistency will be determined. This part is subdivided into the following components:

a. First year requirements covering the mapping and designation of Chesapeake Bay Preservation Areas and the employment of the performance criteria;.

b. Second year program elements, including (i) necessary changes in local zoning and subdivision ordinances and comprehensive plans, (ii) implementation of a local process to review development proposals in preservation areas for compliance with the Act and regulations, (iii) conditions under which water quality impact assessments will be required for proposal developments, and (iv) review by the board of completed local programs for consistency and, upon request, board certification of local programs.

Part VI, "Enforcement," establishes informal and formal administrative procedures to secure compliance, ending with referral to the Attorney General's office for legal proceedings.

VR 173-02-00. Chesapeake Bay Preservation Area Designation and Management Regulations.

PART I. *INTRODUCTION.*

§ 1.1. Application.

The board is charged with the development of regulations including criteria that will provide for the protection of water quality and conservation of habitat dependent on water quality in Chesapeake Bay Preservation Areas, and that also will accommodate economic development. All counties, cities, and towns in

Tidewater Virginia shall comply with these regulations. Other local governments not in Tidewater Virginia are encouraged to use the criteria, and to conform their ordinances as provided in these regulations to protect the quality of state waters in accordance with § 10.1-2110 of the Code of Virginia.

§ 1.2. Authority for regulations.

These regulations are issued under the authority of §§ 10.1-2103 and 10.1-2107 of Chapter 21 of Title 10.1 of the Code of Virginia (the Chesapeake Bay Preservation Act, hereinafter "the Act").

§ 1.3. Purpose of regulations.

These regulations establish the criteria that counties, cities, and towns (hereinafter "local governments") must use to determine the extent of the Chesapeake Bay Preservation Areas within their jurisdictions. They establish criteria for use by local governments in granting, denying, or modifying requests to rezone, subdivide, or to use and develop land in Chesapeake Bay Preservation Areas. They identify the requirements for changes which local governments must incorporate into their comprehensive plans, zoning ordinances, and subdivision ordinances to protect the quality of state waters pursuant to §§ 10.1-2109 and 10.1-2111 of the Act.

§ 1.4. Definitions.

The following words and terms used in these regulations have the following meanings, unless the context clearly indicates otherwise. In addition, some terms not defined herein are defined in § 10.1-2101 of the Act.

"Act" means the Chesapeake Bay Preservation Act found in Chapter 21 (§ 10.1-2100 et seq.) of Title 10.1 of the Code of Virginia.

"Board" means the Chesapeake Bay Local Assistance Board.

"Buffer zone" means an area of natural or established vegetation managed to protect aquatic, wetland, shoreline and other habitat dependent on water quality from significant degradation due to man-made disturbances.

"Chesapeake Bay Preservation Area" means any land designated pursuant to Part III of these regulations and § 10.1-2107 of the Act. A Chesapeake Bay Preservation Area shall not consist of a Resource Protection Area and a Resource Management Area.

"Department" means the Chesapeake Bay Local Assistance Department.

"Development" means the construction, redevelopment or substantial alteration of residential, commercial, industrial, institutional, recreation, transportation, or utility facilities or structures.

"Director" means the Executive Director of the Chesapeake Bay Local Assistance Department.

"Floodplain" means an area that would be inundated as a result of a storm event of a 100-year return interval.

"Highly erodible soils" means soils with an erodibility (K) value greater than .35 of all soils on slopes with a gradient exceeding 15%, as identified in local Soil Surveys published by the U.S. Department of Agriculture-Soil Conservation Service, where such surveys exist.

"Highly permeable soils" means soils with a high potential for transmission of pollutants into groundwater, as identified in the soils information section of the Field Office Technical Guides published by the U.S. Department of Agriculture-Soil Conservation Service.

"Local governments" means counties, cities, and towns. These regulations apply to local governments in Tidewater Virginia, as defined in § 10.1-2101 of the Act, but the provisions of these regulations may be used by other local governments.

"Local program" means the measures by which a local government complies with the Act and regulations.

"Nontidal wetlands" means those wetlands other than tidal wetlands that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support a prevalence of vegetation typically adapted for life in saturated soil conditions, as defined by the U.S. Environmental Protection agency pursuant to § 404 of the federal Clean Water Act as amended, in 33 C.F.R. 328.3b, dated November 13, 1986.

"Redevelopment" means the process of developing land that is or has been developed.

"Redevelopment Management Area" means that component of the Chesapeake Bay Preservation Area that is not classified as the Resource Protection Area.

"Resource Protection Area" means that component of the Chesapeake Bay Preservation Area comprised of sensitive lands at or near the shoreline that have an intrinsic water quality value due to the ecological and biological processes they perform or are sensitive to impacts which may result in significant degradation to the quality of state waters and loss of aquatic habitat.

"Subdivision" means the division of a parcel of land into three or more lots or parcels of less than five acres each for the purpose of transfer of ownership or building development, or, if a new street is involved in such division, any division of a parcel of land. The term includes resubdivision.

"Tidal shoreline" means land contiguous to a tidal body of water to an elevation one and one-half times the local

tide range above the mean low water level.

"Tidal wetlands" means vegetated and nonvegetated wetlands as defined in § 62.1-13.2 of the Code of Virginia.

"Tidewater Virginia" means those jurisdictions named in § 10.1-2101 of the Act.

"Tributary stream" means any perennial stream that is so depicted on the most recent U.S. Geological Survey 7-1/2 minute topographic quadrangle map (scale 1:24,000).

"Use" means activity on the land other than development, including, but not limited to agriculture, horticulture, silviculture, and recreation.

"Water-dependent facility" means a development of land that cannot exist outside of the Resource Protection Area and must be located on the shoreline by reason of the intrinsic nature of its operation. These facilities include, but are not limited to (i) ports; (ii) the intake and outfall structures of power plants, water treatment plants, sewage treatment plants, and storm sewers; (iii) marinas and other boat docking structures; (iv) beaches and other public water-oriented recreation areas, and (v) fisheries or other marine resources facilities.

§ 1.5. Local government discretion.

These regulations represent minimum criteria to be used by localities.

PART II.
LOCAL GOVERNMENT PROGRAMS.

§ 2.1. Local program development.

Local governments shall develop measures (hereinafter called "local programs") necessary to comply with the Act and regulations. Counties and towns are encouraged to cooperate in the development of their local programs. In conjunction with other state water quality programs, local programs shall encourage and promote: (i) protection of existing high quality state waters and restoration of all reasonable public uses and will support the propagation and growth of all aquatic life, including game fish, which might reasonably be expected to inhabit them; (ii) safeguarding the clean waters of the Commonwealth from pollution; (iii) prevention of any increase in pollution; (iv) reduction of existing pollution; and (v) promotion of water resource conservation in order to provide for the health, safety and welfare of the present and future citizens of the Commonwealth.

§ 2.2. Elements of program.

Local programs shall contain the elements listed below. Elements A and B shall be adopted concurrently 12 months after the effective date of these regulations. Elements C through G may be in place within 24 months after the effective date.

A. A zoning map designating Chesapeake Bay Preservation Areas.

B. Performance criteria applying in Chesapeake Bay Preservation Areas at least as stringent as those provided in Part IV.

C. A comprehensive plan or revision that incorporates the protection of Chesapeake Bay Preservation Areas and of the quality of state waters.

D. A zoning ordinance or revision that (i) incorporates measures to protect the quality of state waters in Chesapeake Bay Preservation Areas, (ii) requires compliance with all criteria set forth in Part IV, and (iii) requires a plan of development prior to the issuance of a building permit to assure that use and development of land in Chesapeake Bay Preservation Areas are accomplished in a manner that protects the quality of state waters.

E. A subdivision ordinance or revision that (i) incorporates measures to protect the quality of state waters in Chesapeake Bay Preservation Areas, and (ii) assures that all subdivisions in Chesapeake Bay Preservation Areas comply with the criteria set forth in Part IV.

F. An erosion and sediment control ordinance or revision that requires compliance with the criteria in Part IV.

G. A building permit process or revision that requires compliance with the criteria set forth in Part IV.

PART III.
CHESAPEAKE BAY PRESERVATION AREA DESIGNATION CRITERIA.

§ 3.1. Purpose.

The criteria in this part provide direction for local government designation of the ecological and geographic extent of Chesapeake Bay Preservation Areas. Chesapeake Bay Preservation Areas are divided into Resource Protection Areas and Resource Management Areas that are subject to the criteria in Part IV and the requirements in Part V.

§ 3.2. Resource Protection Areas.

A. Resource Protection Areas shall consist of sensitive lands at or near the shoreline that have an intrinsic water quality value due to the ecological and biological processes they perform and are sensitive to impacts which may cause significant degradation to the quality of state waters or loss of aquatic habitat.

B. As a minimum, the Resource Protection Area shall include:

1. Tidal wetlands;

2. Nontidal wetlands hydrologically connected by surface flow and contiguous to tidal wetlands or tributary streams;

3. Tidal shorelines;

4. Such other lands as might qualify under the provisions of subsection A of § 2.2 of this part that local governments deem necessary to protect the quality of state waters.

5. A vegetated buffer zone located adjacent to and landward of the components listed in subdivisions 1 through 4 above, and along both sides of any tributary stream.

a. The purpose of the buffer zone is to (i) provide for the removal or reduction of sediments, nutrients, and potentially harmful or toxic substances in runoff entering the Bay and its tributaries; (ii) minimize the adverse effects of human activities on wetlands, shorelines, state waters, aquatic resources, and habitat dependent on water quality; and (iii) maintain the natural environment of streams.

b. The width of the buffer zone shall be (i) 100 feet landward of all other components of Resource Protection Areas contiguous to tidal waters, or (ii) 50 feet landward of all other components of Resource Protection Areas contiguous to nontidal waters.

§ 3.3. Resource Management Areas.

A. Resource Management Areas shall include land types that, if improperly used or developed, have a potential for causing significant water quality degradation or for causing a loss of the functional value of the Resource Protection Area.

B. A Resource Management Area shall be provided contiguous to the entire inland boundary of the Resource Protection Area. The following land categories shall be considered for inclusion in the Resource Management Area:

1. Floodplains;

2. Highly erodible soils, including steep slopes;

3. Highly permeable areas or other areas vulnerable to groundwater degradation;

4. Nontidal wetlands not included in the Resource Protection Area;

5. Such other lands as might qualify under the provisions of subsection A of § 3.3 of this part that local governments deem necessary to prevent nonpoint source pollution of state waters.

C. Resource Management Areas shall encompass a land area large enough to provide significant water quality protection through the employment of the criteria in Part IV and the requirements in Parts II and V.

PART IV.
LAND USE AND DEVELOPMENT PERFORMANCE CRITERIA.

§ 4.1. Purpose.

The purpose of this part is to implement the goals of the Act and Part II by establishing criteria to reduce nonpoint source pollution loads entering the Bay, its tributaries and other state waters, to protect the functional integrity of the Resource Protection Area, and to conserve water resources.

These criteria are supplemental to the various planning and zoning concepts employed by local governments in granting, denying, or modifying requests to rezone, subdivide, or to use and develop land in Chesapeake Bay Preservation Areas.

§ 4.2. General performance criteria.

It must be demonstrated to the satisfaction of local governments that any use, development, or redevelopment of land in Chesapeake Bay Preservation Areas meets the following performance criteria:

1. No more land shall be disturbed than is necessary to provide for the desired use or development.

2. Natural vegetation shall be preserved to the maximum extent possible.

3. Nonstructural best management practices shall be employed rather than structural best management practices where either will perform the required function. In any case, best management practices utilized shall be self-maintaining or regular maintenance of their function must be ensured.

4. All development of land shall be accomplished through a plan of development review process consistent with § 15.1-491 (h) of the Code of Virginia.

5. Land development shall minimize impervious cover.

6. All subdivision lots platted after the effective date shall provide sufficient area for the construction of the principal structure, accessory structures, access road or driveway, and necessary on-site treatment facilities outside the Resource Protection Area.

7. Any land disturbing activity that exceeds an area of 2,500 square feet (including construction of all single family houses, septic tanks and drainfields, but *otherwise as defined in § 10.1-560 of the Code of Virginia) shall comply with the requirements of the local erosion and sediment control ordinance.*

8. On-site sewage treatment systems not requiring a State Water Control Board permit shall:

a. Have inspection and pump-out accomplished at least every five years;

b. Provide a reserve drainfield site equal to the area of the primary drainfield site. The reserve drainfield site shall be shown on the plat map and building shall be prohibited on the area of the reserve drainfield;

c. Require a minimum vertical separation distance between the septic absorption area and the seasonally high water table of at least 18 inches at all times of the year.

9. Stormwater management criteria at least as stringent as the following apply:

a. Sheet flows shall be maintained and concentrated flows avoided to the maximum extent possible;

b. For new development, the post-development nonpoint source pollution runoff load shall not exceed the predevelopment load based upon average land cover conditions;

c. Redevelopment shall result in a 10% reduction of nonpoint source pollution in runoff compared to the existing runoff load from the site.

10. Agricultural lands shall have a soil and water conservation plan approved by the local Soil and Water Conservation District by January 1, 1995.

11. Where nontidal wetlands exist on the site, the following criteria apply:

a. Disturbance of nontidal wetlands or alteration of their biological function or character shall be avoided. Man-made nontidal bodies of water, including farm and stock ponds, irrigation ditches, drainage ditches and stormwater management best management practices other than created wetlands, are not considered wetlands by these regulations. However, man-made vegetated wetlands created as water quality best management practices or for purposes of compensation shall be considered equivalent to natural wetlands.

b. Except as provided in subsection B of § 4.3 of this part, if disturbance or alteration of nontidal wetlands cannot be completely avoided and exceeds an area of 10,000 square feet, the disturbed or altered area shall be replaced by at least an equal area of compensation wetlands on the site or within the same watershed wherever possible. Compensation wetlands shall be protected by perpetual conservation easements or other method of comparable effect.

c. Silvicultural activities shall implement best management practices for wetlands as established by the Virginia Department of Forestry. Notice that a logging operation is about to commence shall be given to appropriate officials of the Virginia Department of Forestry.

d. Local governments shall require evidence of all nontidal wetlands permits required by law prior to authorizing grading or other on-site activities to begin.

§ 4.3. Performance criteria for Resource Protection Areas.

The following criteria shall apply specifically within Resource Protection Areas and supplement the general performance criteria in § 4.2 of this part.

A. Allowable development.

A water quality impact assessment shall be required for any proposed development in accordance with Part V. Land development may be allowed only if it (i) is water dependent or (ii) constitutes redevelopment.

1. A new or expanded water-dependent facility may be allowed provided that:

a. It does not conflict with the comprehensive plan;

b. It complies with the performance criteria set forth in this part;

c. Any nonwater-dependent component is located outside of Resource Protection Areas;

d. Marina and community boat mooring locations conform to criteria established by the Virginia Marine Resources Commission;

e. Access will be provided with the minimum disturbance necessary. Where possible, a single point of access will be provided.

2. Redevelopment shall conform to all applicable criteria in this part.

B. Nontidal wetlands.

Subject to the additional criteria in § 4.2 of this part, any disturbed or altered area of nontidal wetlands shall be replaced by compensation nontidal wetlands of at least twice the area of the wetlands disturbed or altered.

C. Buffer zone requirements.

In order to satisfy the buffer zone requirements, appropriate vegetation shall be established where it does not exist naturally. Otherwise, the following performance criteria shall apply:

1. Natural vegetation shall be preserved to the maximum extent possible, with the following exception:

a. For shoreline erosion control projects, trees and woody vegetation may be removed, necessary control structures built, and appropriate vegetation established to protect or stabilize the shoreline in accordance with the best available technical advice and applicable permit conditions or requirements;

b. In order to maintain the functional value of the buffer zone, vegetation may be removed only to provide for reasonable sight lines, access path, and general woodlot management.

2. When the application of the buffer zone would result in the loss of a buildable area on a lot or parcel recorded prior to the effective date, modifications to the width of the buffer zone may be allowed in accordance with the following criteria:

a. Modifications to the buffer zone shall be the minimum necessary to achieve a reasonable buildable area for a principal structure and necessary utilities;

b. Where possible, an area equal to the area encroaching the buffer zone shall be estimated elsewhere on the lot or parcel in a way to maximize water quality protection;

c. In no case shall the reduced portion of the buffer zone be less than 50 feet in width.

3. In agricultural lands:

a. Where a naturally vegetated buffer zone up to the width required in Part III exists, it shall be maintained;

b. Existing agricultural activities in the buffer zone area shall maintain, as a minimum best management practice, a 25-foot wide vegetated filter strip measured landward from the mean high water level of tidal waters or tributary streams, or from the landward edge of any wetlands. The filter strip is not required for agricultural drainage ditches if the adjustment agricultural land has in place best management practices in accordance with a conservation plan approved by the local Soil and Water Conservation District;

c. The filter strip shall be composed of either trees with a dense ground cover, a thick sod of grass, or an appropriate legume cover and shall be managed to prevent concentrated flows of surface water from breaching the strip and noxious weeds (such as Johnson grass, kudzu, and multiflora rose) from invading the strip;

d. The filter strip shall be maintained until the landowner has implemented a program of Best Management Practices that improve water quality in accordance with a conservation plan approved by the local Soil and Water Conservation District, provided that the portion of the conservation plan being implemented for the Resource Protection Area achieves water quality protection at least the equivalent of that provided by the filter strip.

4. Silvicultural activities shall maintain, as a minimum best management practice, a streamside management zone extending the full width of the buffer zone landward from all other components of Resource Protection Areas, in accordance with criteria developed by the Virginia Department of Forestry.

§ 4.4. Incorporation into local programs.

Local governments shall incorporate the criteria in this part, or provisions at least the equivalent thereof, into their comprehensive plans, zoning ordinances, subdivision ordinances, and such other police and zoning powers as may be appropriate, in accordance with §§ 10.1-2111 and 10.1-2108 of the Act and Part V of these regulations. The criteria may be employed in conjunction with other planning and zoning concepts to protect the quality of state waters.

§ 4.5. Exceptions to the criteria.

Exceptions to the requirements of these regulations may be granted if: (i) strict application of the criteria will result in undue hardship unique to the particular situation of the applicant and (ii) granting the exception will not result in an increase of nonpoint source pollution over what would have resulted if the criteria had been applied.

A. Exceptions to the criteria shall be the minimum necessary to afford relief.

B. Reasonable and appropriate conditions upon any exception granted shall be imposed as necessary so that the purpose and intent of the Act is preserved.

PART V.
IMPLEMENTATION, ASSISTANCE, AND DETERMINATION OF CONSISTENCY.

§ 5.1. Purpose.

The purpose of this part is to assist local governments in the timely preparation of local programs to implement the Act, and to establish guidelines for determining local program consistency with the Act.

§ 5.2. Schedule of program adoption.

To ensure timely achievement of the requirements of the Act and timely receipt of assistance, local governments should adhere to the following schedule for the completion of program elements and their submission to the board for its information. The following schedule should be inititated and completed after the effective date of these regulations:

1. First year schedule.

a. Work plan within two months.

b. Proposed program for the designation of Chesapeake Bay Prevention Areas and adoption of performance criteria within six months.

c. Public hearings to designate Chesapeake Bay Preservation Areas and adopt performance criteria at the earliest possible date.

d. Work plan for second program year within nine months.

e. Local designation of Chesapeake Bay Preservation Areas and adoption of performance criteria must occur within 12 calendar months.

2. Second year schedule.

a. Proposed program for full implementation of the Act and regulations within 20 months.

b. Local adoption of complete local program within 24 months.

§ 5.3. First year program elements.

A. The board will establish liaison with each local government to assist that local government in developing and implementing its local program in obtaining technical and financial assistance, and in complying with the Act and regulations.

B. Program work plan.

Local governments should provide the board with a tentative work plan for accomplishing their program which should include:

1. Identification and description of elements of the local program;

2. Identification of specific tasks necessary to achieve each program element and the responsible department or agency to perform each task;

3. Maps and resources to be used to designate Chesapeake Bay Preservation Areas;

4. Tentative dates for completion of program elements;

5. Anticipated needs for technical and financial assistance for specified program elements.

C. Planning district comments.

Local governments are encouraged to enlist the assistance and comments of regional planning district agencies early in the development of their local programs. Any comments from the regional planning district agency should be taken into consideration prior to completion and submission of a work plan.

D. Preliminary review by the board.

The board will review a work plan within 30 days. If it appears consistent with the Act, the board will schedule a conference with the local government to determine what technical and financial assistance may be needed and can be supplied to accomplish the work plan. If not, the board will notify the local government and recommend specific changes.

E. Designation of Chesapeake Bay Preservation Areas.

Local governments shall designate Chesapeake Bay Preservation Areas within 12 months after the effective date of these regulations. To assure timely adoption, they should prepare a proposed designation program and submit it to the board. The program should:

1. Inventory and analyze wetlands, nontidal wetlands, tidal shorelines, tributary streams, flood plains, highly erodible soils including steep slopes, highly permeable areas, and other sensitive environmental resources as necessary to comply with Part III.

2. Determine, based upon the inventory and analysis, the extent of Chesapeake Bay Preservation Areas within its jurisdiction.

3. Prepare a map delineating Chesapeake Bay Preservation Areas.

4. Prepare amendments to local ordinances which incorporate the performance criteria of Part IV or the model ordinance prepared by the board.

F. Review by the board.

The board will review a proposed designation program within 60 days. If it is consistent with the Act, the board will schedule a conference with the local government to determine what additional technical and financial assistance may be needed and can be supplied to accomplish the proposed program. If not, the board will notify the local government and recommend specific changes.

G. Adoption of first year program.

As soon as possible after being advised of program consistency, local governments shall hold a public hearing, *designate Chesapeake Bay Preservation Areas as an amendment to the local zoning map, and adopt the performance criteria. Copies of the adopted program documents and subsequent changes thereto, shall be provided to the board.*

§ 5.4. Second year program elements.

A. Work plan.

Within nine months after the effective date, local governments should provide a second year work plan to the board.

B. Preliminary review by the board.

The board will review the work plan within 30 days. If it is consistent with the Act, the board will schedule a conference with the local government to determine what technical and financial assistance may be needed and can be supplied to accomplish the work plan. If not, the board will notify the local government and recommend specific changes.

C. Preparation and submission of management program.

Within 20 months after the effective date, local governments should submit to the board completed local program documents, including any revisions to comprehensive plans, zoning ordinances, subdivision changes, and other local authorities necessary to implement the Act. Prior to adoption, local governments may submit any proposed revisions to the board for comments. Guidelines are provided below for local government use in preparing local programs and the board's use in determining local program consistency.

1. Comprehensive plans. Local governments shall review and revise their comprehensive plans, as necessary, for compliance with § 10.1-2109 of the Act. As a minimum, the comprehensive plan or plan component should consist of the following basic elements: (i) a summary of data collection and analysis; (ii) a policy discussion; (iii) a land use plan map; (iv) implementing measures, including specific objectives and a time frame for accomplishment.

a. Local governments should establish an information base from which to make policy choices about future land use and development that will protect the quality of state waters. This element of the plan should be based upon the following:

(1) Inventories and analyses used to designate Chesapeake Bay Preservation Areas;

(2) Other marine resources and marine habitat;

(3) Shoreline erosion problems and location of erosion control structures;

(4) Conflicts between existing and proposed land uses and water quality;

(5) A map or map series, accurately representing the above information.

b. As part of the comprehensive plan, local governments should clearly indicate local policy on land use issues relative to water quality protection. Local governments should ensure consistency among the policies developed.

(1) Local governments should discuss each component of Chesapeake Bay Preservation Areas in relation to the types of land uses considered appropriate and the reasons for including each type of land use.

(2) As a minimum, local governments should prepare policy statements for inclusion in the plan on the following issues:

(a) Physical constraints to development, including soil limitations, with an explicit discussion of soil suitability for septic tank use;

(b) Protection of potable water supply, including groundwater resources;

(c) Relationship of land use to commercial and recreational fisheries, including nursery and habitat areas;

(d) Appropriate density for docks and piers;

(e) Public and private access to waterfront areas and effect on water qaulity;

(f) Existing pollution sources;

(g) Potential water quality improvement through the redevelopment of intensely developed areas.

(3) For each of the policy issues listed above, the plan should contain a discussion of the scope and importance of the issue, alternative policies considered, the policy adopted by the local government for that issue, and a description of how the local policy will be implemented.

(4) Within the policy discussion, local governments should address consistency between the plan and all adopted land use, public services, land use value taxation ordinances and policies, and capital improvement plans and budgets.

c. Water-dependent facilities.

(1) Local governments should include in their comprehensive plans a plan for water-dependent facilities. As a minimum, local governments should

consider the following factors in the planning process:

(a) Impact of water-dependent uses on water quality;

(b) Existing wetlands, submerged aquatic plant beds, shellfish beds, anadramous fish spawning grounds, and other important habitat dependent on water quality;

(c) Extent and effects of any dredging required, including placment of dredged material;

(d) Compatibility of current land uses with water quality protection goals.

(2) Local governments should prepare an analysis of the capacity of existing water-dependent facilities and future demands. This analysis should address marinas, boat ramps, public docks, shoreline fishing areas, and other public access to the waterfront or beach. Areas currently zoned for water-dependent facilities should also be evaluated.

(3) Local governments should identify areas suitable for water-dependent facilities with respect to other comprehensive plan policies and in accordance with performance criteria in Part IV.

2. Zoning ordinances. Local governments shall review and revise their zoning ordinances, as necessary, to comply with § 10.1-2109 of the Act. The ordinances should:

a. Make provisions for the protection of Chesapeake Bay Preservation Areas;

b. Incorporate either explicitly or by direct reference, the performance criteria in Part IV;

c. Be consistent with the comprehensive plan within Chesapeake Bay Preservation Areas.

3. Plan of development review. Local governments shall make provisions as necessary to ensure that any development of land within Chesapeake Bay Preservation Areas must be accomplished through a plan of development procedure pursuant to § 15.1-491(h) of the Code of Virginia to ensure compliance with the Act and regulations. Any exemptions from those review requirements shall be established and administered in a manner that ensures compliance with these regulations.

4. Subdivision ordinances. Local governments shall review and revise their subdivision ordinances, as necessary, to comply with § 10.1-2109 of the Act. The ordinances should:

a. Include language to ensure the integrity of Chesapeake Bay Preservation Areas;

b. Incorporate, either explicitly or by direct reference, the performance criteria of Part IV.

5. Water quality impact assessment. A water quality impact assessment shall be required for any proposed development within the Resource Protection Area consistent with Part IV and for any other development in Chesapeake Bay Preservation Areas that may warrant such assessment because of the unique characteristics of the site or intensity of the proposed use or development. Local governments should notify the board of all development requiring a water quality impact assessment. Upon request, the board will provide review and comment on any water quality impact assessment within 90 days, in accordance with advisory state review requirements of § 10.1-2112 of the Act.

D. Review by the board.

The board will review a proposed management program within 90 days. If it is consistent with the Act, the board will schedule a conference with the local government to determine what additional technical and financial assistance may be needed and can be supplied to accomplish the long-term aspects of the local program. If the program or any part thereof is not consistent, the board will notify the local government in writing stating the reasons for a determination of inconsistency and recommending specific changes. Copies of the adopted program documents and subsequent changes thereto, shall be provided to the board.

§ 5.5. Certification of local program.

Upon request, the board will certify that a local program complies with the Act and regulations.

PART VI.
ENFORCEMENT.

§ 6.1. Applicablity.

The Act requires that the board ensure that local governments comply with the Act and regulations and that their comprehensive plans, zoning ordinances, and subdivision ordinances are in accordance with the Act. To satisfy these requirements, the board has adopted these regulations and will monitor each local government's compliance with the Act and regulations.

§ 6.2. Informal proceedings.

Prior to instituting notice and formal hearing proceedings or making a finding of noncompliance, the board will attempt through informal administrative proceedings to secure local program compliance with the Act.

§ 6.3. Notice and formal hearing.

When the board formally reviews a local government's compliance with the Act and regulations, it shall give the local government at least 15 days notice of the time and place of its next meeting and of intention to then hear evidence on the local government's compliance. Evidence will be received from the staff and from the local government.

§ 6.4. Finding of noncompliance.

Upon a finding of noncompliance, the board will refer the matter for legal action.

DEPARTMENT OF GAME AND INLAND FISHERIES (BOARD OF)

NOTE: The Board of Game and Inland Fisheries is exempted from the Administrative Process Act (§ 9-6.14:4 of the Code of Virginia); however, it is required by § 9-6.14:22 to publish all proposed and final regulations.

Title of Regulations:

VR 325-01. DEFINITIONS AND MISCELLANEOUS.
- VR 325-01-1. Definitions and Miscellaneous.

VR 325-02. GAME.
- VR 325-02-1. In General.
- VR 325-02-2. Bear.
- VR 325-02-6. Deer.
- VR 325-02-8. Fox.
- VR 325-02-9. Grouse.
- VR 325-02-16. Pheasant.
- VR 325-02-17. Quail.
- VR 325-02-18. Rabbit.
- VR 325-02-19. Raccoon.
- VR 325-02-21. Squirrel.
- VR 325-02-22. Turkey.
- VR 325-02-25. Firearms.

VR 325-04. WATERCRAFT.
- VR 325-04-4. Accident and Casualty Reporting.

Statutory Authority: §§ 29.1-501, 29.1-502 and 29.1-701 of the Code of Virginia.

Proposed Effective Date: July 1, 1989

Public Hearing Date: May 5, 1989 - 9:30 a.m.
(See Calendar of Events section for additional information)

Public Hearing Notice:

The Board of Game and Inland Fisheries has ordered to be published, pursuant to §§ 29.1-501 and 29.1-502 of the Code of Virginia, the following proposed new and amended board regulations. A public hearing on the advisability of adopting, or amending and adopting, the proposed regulations, or any part thereof, will be held at the Holiday Inn I-64, West End, 6531 West Broad Street, Richmond, Virginia, beginning at 9:30 a.m. on Friday, May 5, 1989, at which time any interested citizen present shall be heard. If the board is satisfied that the proposed regulations, or any part thereof, are advisable, in the form in which published or as amended as a result of the public hearing, the board may adopt such proposals at that time, acting upon the proposals separately or in block.

Summary:

Summaries are not provided since, in most instances, the summary would be as long or longer than the full text.

VR 325-01. DEFINITIONS AND MISCELLANEOUS.

VR 325-01-1. Definitions and Miscellaneous.

§ 10. Prohibited use of vehicles on department-owned lands.

It shall be unlawful on department-owned lands to drive through or around gates designed to prevent entry with any type of motorized vehicle or to use such vehicles to travel anywhere on such lands except on roads open to vehicular traffic. *Any motor-driven conveyance shall conform with all state laws for highway travel; provided, that this requirement shall not apply to the operation of motor vehicles for administrative purposes by department-authorized personnel on department-owned lands.*

§ 14. Structures on department-owned lands.

A. It shall be unlawful to construct, maintain or occupy any permanent structure, except by permit, on department-owned lands. This provision shall not apply to structures, stands or blinds provided by the department.

B. It shall be unlawful to maintain any temporary dwelling on department-owned lands for a period greater than 14 consecutive days. Any person constructing or occupying any temporary structure shall be responsible for complete removal of such structures when vacating the site.

C. It shall be unlawful to construct, maintain or occupy any tree stand on department-owned lands; provided, that portable tree stands which are not permanently affixed may be used.

VR 325-02. GAME.

VR 325-02-1. In General.

§ 3. Recorded wild animal or wild bird calls or sounds prohibited in taking game; coyotes and crows excepted.

It shall be unlawful to take or attempt to take wild

APPENDIX C

PRELIMINARY CRITICAL AQUATIC HABITAT INVENTORY

WETLANDS

The occurrence of wetlands in each of the four categories of water bodies identified for the purposes of this report is discussed below. For the purposes of this inventory, wetlands are categorized as fringe, extensive, or embayed marshes, marsh islands, or forested wetlands. A fringe marsh parallels a shoreline and generally has a greater length than width. An extensive marsh has considerable acreage, its length and width are roughly comparable and it projects into an estuary. An embayed marsh occupies a drowned creek valley. A marsh island is an isolated marsh surrounded on all sides by open water. Each marsh system can be either tidal or non-tidal and can be associated with fresh, brackish or salt water. Forested wetlands are non-tidal, are associated with freshwater, are often only seasonally flooded, and are generally comprised of hardwood tree species.

MAJOR RECEIVING WATERS

Most of the shoreline along the lower Chesapeake Bay, Hampton Roads and the lower James River is comprised of beach, and/or is artificially stabilized. The beach intertidal zone is technically considered a wetland. In Southeastern Virginia, stormwater discharges into the beach intertidal zone occur in several locations along ocean and bay beaches. These discharges, however, are extremely localized and have minimal water quality impacts. They are therefore not addressed in this study. There are some tidal marshes associated with the region's major receiving waters. Intermittent stretches of fringe marsh are found along the Hampton Roads shoreline from Craney Island to Chuckatuck Creek. These marshes are often fronted by tidal mudflats. Ragged Island, an extensive marsh system comprising nearly 1500 acres, is located on Hampton Roads immediately downstream of the James River Bridge (U.S. 17). There are also 240 acres of embayed marsh along the minor creeks that flow directly into these water bodies (i.e., Hoffler Creek, Streeter Creek, Bailey Beach and Rushmere Shores).

TIDAL TRIBUTARIES

Salt and brackish water marshes are integral components of the estuaries that are tributary to the Atlantic Ocean, the Chesapeake Bay, Hampton Roads and the James River. Fringe and embayed marshes are present in all of the region's estuaries, while all of the identified categories of marsh are common only in the larger systems. In addition, nonvegetated wetlands in the form of tidal mudflats are associated with most of these marsh systems. Table 1 contains estimates of marsh acreage for each of the water bodies included in this category. Forested wetlands are also found in the upper, nontidal reaches of the Nansemond River, Chuckatuck Creek, Pagan River and Lawnes Creek systems. Acreage figures for these wetlands are unavailable.

TABLE 1

TIDAL MARSH ACREAGE IN SOUTHEASTERN VIRGINIA ESTUARIES

Rudee Basin	103	
Lynnhaven River	859	
Little Creek	154	
Elizabeth River	1,845	
Nansemond River	4,500	(est.)
Chuckatuck Creek	1,082	(est.)
Pagan River	3,260	
Lawnes Creek	445	
TOTAL	12,248	

Sources: Virginia Institute of Marine Science, Tidal Marsh Inventories for Virginia Beach, Norfolk and Isle of Wight County, and personal communication with Ken Moore 12/5/88.

Woolpert Consultants, Coastal Zone Management Plan: City of Portsmouth Virginia, 1988.

Hampton Roads Water Quality Agency, Hampton Roads Water Quality Management Plan: Appendix 9, 1976.

THE BACK BAY AND FREE-FLOWING RIVERS

Forested wetland is the predominant wetland type found along most of these water bodies. The one exception is the Back Bay where brackish water marsh predominates. The Bay watershed contains approximately 11,400 acres of brackish water extensive, fringe, embayed and island marshes, and only 2,400 acres of forested wetlands.[1] The North Landing River watershed, on the other hand, contains approximately 3,900 acres of brackish water marsh and approximately 34,000 acres of forested wetland.[2,3] Few marshes, but vast areas of forested wetlands are found along the Virginia portions of the Northwest, Blackwater, Nottoway and Meherrin rivers. Wetland acreage figures for these waterways are unavailable.

LAKES

Since most of the region's lakes are manmade and were created through either excavation or the flooding of lowlands, wetlands are generally not present. The only exceptions are Lake Drummond, the region's only natural lake, which is surrounded by forested wetland, and Stumpy Lake which also has areas of forested wetland along portions of its shoreline.

SUBMERGED AQUATIC VEGETATION

MAJOR RECEIVING WATERS

Formal SAV surveys conducted since the early 1970s have found no significant concentrations of SAV in the portions of these water bodies that are contiguous to Southeastern Virginia. Little is known about the historic distribution of SAV in the lower Chesapeake Bay, Hampton Roads and the lower James River. Anecdotal accounts indicate that, prior to the early 1960s, there were extensive stands of SAV in the lower James River above the James River Bridge.[4]

[1]Roy Mann Associates, Inc., A Management Plan for the Back Bay, Volume II: Water Quality, (Boston, Massachusetts: Roy Mann Associates, Inc., 1985), p. 5-2.

[2]Virginia Institute of Marine Science, City of Virginia Beach Marsh Inventory: Volume 1, North Landing River and Tributaries, Gloucester Point, Virginia: VIMS, 1976.

[3]Roy Mann Associates, Inc. A Management Plan the Back Bay, Volume I: Main Report, (Boston, Massachusetts: Roy Mann Associates, 1984), p. 18.

[4]Personal communication with Dr. Robert J. Orth of the Virginia Institute of Marine Science, January 6, 1989.

TIDAL TRIBUTARIES

As with the major receiving waters, there is little historical information regarding the distribution of SAV in the region's tidal tributaries. However, given the depth contours and salinities of these water bodies, and the anecdotal accounts of SAV in the James River, it is quite possible that SAV (probably eelgrass) was prevalent.

According to SAV surveys conducted between 1971 and 1986 by the Virginia Institute of Marine Sciences for the entire Chesapeake Bay system, the only Southeastern Virginia tidal water body which has consistently had significant concentrations of SAV is Broad Bay in the Lynnhaven River system. In 1986, Broad Bay had approximately 107 acres of eelgrass and widgeon grass beds. The extent and longevity of the Broad Bay SAV beds is indicative of the Lynnhaven River's ability to support SAV and could lead one to conclude that, historically, the Lynnhaven River system supported a much larger SAV population.[5] Figure 1 shows the general distribution of SAV in Broad Bay in 1986.

THE BACK BAY AND FREE-FLOWING RIVERS

Historically, the quantity and species composition of SAV in the Back Bay have undergone extreme fluctuations. The reasons for these fluctuations are not clearly understood, but are probably related to the combined effect of changes in salinity, turbidity and circulation. Disease may also be a contributing factor. The presence of SAV in the Back Bay reached record levels during the 1970s when the Bay experienced up to 88 percent coverage.[6] This was due to an invasion of a non-native species of SAV known as eurasian watermilfoil. During the early 1980s, the frequency of SAV in the Back Bay began a drastic decline. Between 1981 and 1986, SAV coverage in the Bay dropped from 50 percent to eight percent.[7] Most of the existing vegetation, which is still dominated by eurasian watermilfoil, is found in the southeastern portion of the Bay in the vicinity of False Cape State Park. Figure 2 shows the general distribution of SAV in the Back Bay in 1983.

Little information is available concerning the distribution and species composition of SAV in the region's free flowing rivers. SAV is not common in the main stems of these rivers, but does occur sporadically in tributaries.

[5]Ibid.

[6]Norman, Mitchell D. and Ron Southwick, Back Bay: Report on Salinity and Water Quality in 1986, (Chesapeake, Virginia: Virginia Commission of Games and Inland Fisheries, 1987), Figure 7.

[7]Ibid.

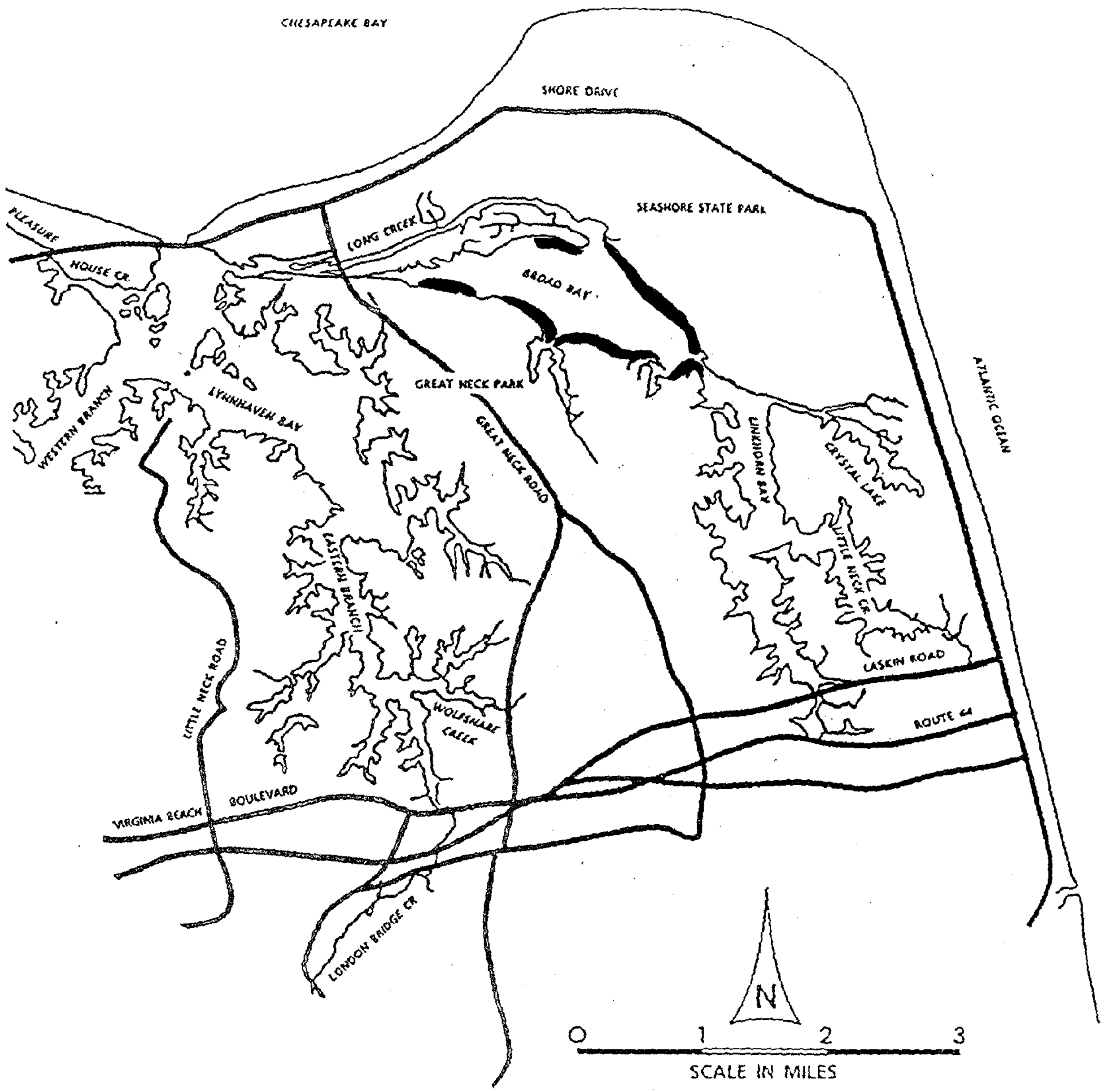
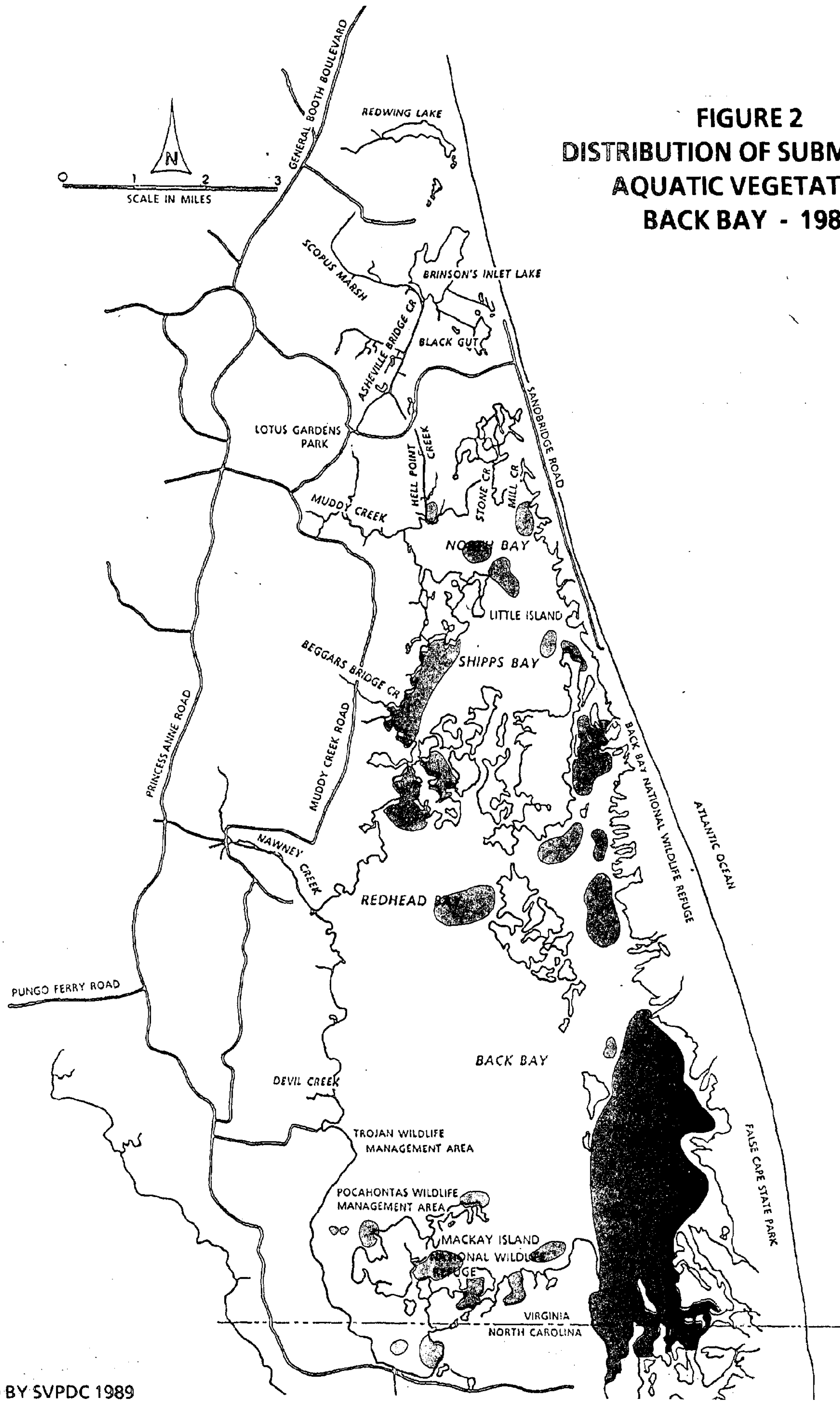


FIGURE 1
DISTRIBUTION OF SUBMERGED AQUATIC VEGETATION BROAD BAY - 1986

PREPARED BY SVPDC 1989
SOURCE: VIMS, 1986

FIGURE 2
DISTRIBUTION OF SUBMERGED AQUATIC VEGETATION BACK BAY - 1983



PREPARED BY SVPDC 1989

SOURCE: Roy Mann Associates, INC., A Management Plan for Back Bay, 1984.

LAKES

Emergent, submergent and floating aquatic vegetation are common in the nearshore areas of most of the region's lakes and reservoirs. Areas of emergent and floating vegetation are technically defined as wetlands, but, because they are rooted under water, these plants are categorized as SAV beds for the purposes of this report. Species of aquatic vegetation found in the region's lakes include cattails, rushes, sedges, pondweeds, duckweeds and water lilies.[8]

SPAWNING GROUNDS

MAJOR RECEIVING WATERS

As mentioned in Chapter II, many of the species of marine fish common to the waters of Southeastern Virginia spawn in the open ocean. However, several estuarine species which are year long residents of the Bay and its tributaries spawn in the lower Chesapeake Bay/Hampton Roads/lower James River area. Some of these species are resident to these waters, while others migrate from upstream tributaries. Estuarine species include bay anchovy, gobies, killifish, silversides and hogchoker. Although not commercially important, these fish are important forage species for marine finfish that enter estuaries during the summer to feed. The exact locations of the spawning areas for these fish will depend on a number of factors including salinity, water temperature, and bottom characteristics. At least two species of forage fish depend on abandoned shells for spawning. The killifish spawns during a spring tide depositing its eggs in shells above the normal high tide line. The eggs then hatch during the next month's spring tide. Gobies spawn from May to October by forming nests and laying eggs in dead oyster shells. Males then guard the nest until the eggs hatch. The interdependence of fish reproduction and SAV is illustrated by the silverside. Silversides spawn in the early spring. Their eggs have adhesive filaments which attach themselves to grasses where they remain until they are hatched.

The blue crab spawns in an area along the south side of the mouth of the Chesapeake Bay. Spawning occurs from mid-spring through summer. To protect spawning blue crabs, a 130 square mile "crab sanctuary" has been designated in which harvests are prohibited between June 1 and September 15.

The James River is a major spawning ground for all anadromous fish species common to Virginia. However, actual spawning occurs well upstream of the Southeastern Virginia region. It is therefore not discussed further in this inventory.

[8]Hampton Roads Water Quality Agency, Hampton Roads Water Quality Management Plan, Appendix 9: Ecological Inventory, (Norfolk, Virginia: HRWQA, 1976), p. 76.

TIDAL TRIBUTARIES

The upper reaches of the region's tidal tributaries are spawning grounds for several species of anadromous and semi-anadromous finfish. Because spawning locations depend on the right balance of a number of environmental conditions which may vary from season to season (i.e., salinity, water temperature, water depth, turbidity, circulation and bottom type), it is impossible to identify specific spawning grounds. Table 2 summarizes the general environmental conditions for and the environmental constraints to successful spawning of anadromous and semi-anadromous fish found in Southeastern Virginia.

THE BACK BAY AND FREE-FLOWING RIVERS

The Back Bay provides spawning habitat for about 20 species of fresh and brackish water species of fish. Several species of semi-anadromous fish are found in the Bay, but spawning runs of anadromous fish do not occur. There is speculation within the scientific community that increased salinity levels, which have averaged 10% sea strength (3.5 ppt) in recent years, have adversely affected the spawning success of nearly all fresh and semi-anadromous brackish water species of finfish.[9] It has been further speculated that the few small creeks and canals that enter the Bay do not provide suitable freshwater "refuges" for spawning.[10] The high salinity levels that were recorded in the Bay in recent years were due to the pumping of saltwater from the ocean into the Bay in an effort to stimulate the growth of SAV. The end of the pumping project in 1987 may initiate a return of adequate freshwater, anadromous and semi-anadromous fish spawning habitat. Tests conducted in the fall of 1988 recorded salinity levels of approximately 2% in coves along the eastern shore of the Bay, and levels of 1% to 2% in adjacent marshes.[11] This may be an indication that baywide salinity levels are already decreasing.

Another problem affecting spawning success is the decreased presence of SAV. Several species of fish that were once numerous in the Bay are dependent on SAV for spawning.

[9]Norman, Mitchell D. and Ron Southwick, Results of Back Bay Fish Sampling, 1985-1986, (Chesapeake, Virginia: Virginia Department of Games and Inland Fisheries, 1987).

[10]Ibid., pp. 9-10.

[11]U.S. Fish and Wildlife Service, Draft Environmental Assessment: Proposal to Expand the Boundary of Back Bay National Wildlife Refuge, Virginia Beach, Virginia, (Newtown Corner, Massachusetts: USFWS, 1988), p. 19.

TABLE 2

ENVIRONMENTAL CONDITIONS FOR SPAWNING OF COMMON ANADROMOUS AND SEMI-ANADROMOUS FISH IN SOUTHEASTERN VIRGINIA

Species	Temperature (°C) and Salinity Conditions	Spawning Areas	Spawning Season	Environmental Constraints
Anadromous				
Alewife	Water temperature: minimum 10.5; peak 18; maximum 29-31. Salinity: Freshwater to salinities less than 0.5 ppt.	Large rivers, small streams and ponds over detritus-covered bottom with vegetation; sometimes at depths about 3 m. Usually ascend streams further than blueback herring.	Late March through April with spawning lasting only a few days for each spawning group.	Usually spawn in sluggish water 15-30 cm deep. The greatest spawning activity occurs at night.
American Shad	Water temperature: minimum 8; peak 17; (Spawning generally occurs at 12°-21°C). Salinity: Tidal-freshwater to 0.5 ppt.	Primarily in tidal-fresh water of rivers with areas of extensive flats; also over sand or pebbly bottom; often near mouths of creeks.	April - May Mid-May and July	Currents less than 0.3 or greater than 0.9 m sec^{-1}; depths of 0.9-12.2 m; eggs absent at less than 5 ppm oxygen.
Blueback Herring	Water temperature: minimum 14; peak 21-26; maximum 27. Salinity: Fresh to brackish waters.	Fresh and brackish rivers and tributaries, never far above tidewater; over bottoms of clean swept sand and gravel to boulders.	April - May	Areas of relatively wide and deep ingress with swift flow.
Striped Bass	Water temperature: minimum 11; peak 14-19; maximum 23. Salinity: Freshwater to salinity less than 3 ppt.	Large rivers and the upper portion of the Bay; spawning is concentrated within the first river kilometer above salt water.	Spawning occurs from the beginning of April through mid-June.	A minimum current of 30 cm sec^{-1} is needed to keep eggs in suspension; optimal currents are 1 - 2 m sec^{-1}. Maximum survival of eggs before water hardening occurs at about 1 ppt salinity.

TABLE 2 (Continued)
ENVIRONMENTAL CONDITIONS FOR SPAWNING OF COMMON ANADROMOUS AND SEMI-ANADROMOUS FISH IN SOUTHEASTERN VIRGINIA

Species	Temperature (°C) and Salinity Conditions	Spawning Areas	Spawning Season	Environmental Constraints
Semi-Anadromous				
White Perch	Water temperature: minimum 7.2-10; peak 11-16; maximum about 20. Salinity: Freshwater to 4 ppt.	Fresh, tidal fresh, or slightly brackish water in rivers, tributary streams, and shallow coves.	Late March to early June: eggs are not released all at once, and ovulation may continue for 10 to 21 days.	A sudden drop in temperature of 2.2 to 2.8°C may kill eggs.
Yellow Perch	Water temperature: minimum 5; peak 8.5-11; maximum 23. Salinity: Freshwater to 2.5 ppt.	Tidal or non-tidal portions of rivers near shore, over substrates of sand, rock, gravel or rubble; typically at depths of 1.5 to 3 m.	Spawning occurs from the end of February to April, with peak activity in mid-March.	Significant growth reduction at 2.0 ppm dissolved oxygen.
White Catfish	Water temperature: peak about 21. Salinity: Freshwater.	Still or running water; nests usually built near sand or gravel banks.	Late May	No information
Brown Bullhead	Water temperature: peak 21-25. Salinity: Freshwater.	Sluggish, weedy, muddy streams and lakes; nests occur in shelter of logs, rocks, or vegetation.	Early April to August throughout the range.	Spawning occurs in early morning to early afternoon. Eggs exposed to sunlight have poor hatching success.
Channel Catfish	Water temperature: minimum 21; peak 27; maximum 29. Salinity: Freshwater to 2ppt.	Nests occur in weedy areas near lake shores, in protected sites, small streams, sometimes in very swift water.	March through July, possibly September; sometimes have two spawning peaks per season.	Growth reduction at less than 3.5 ppm dissolved oxygen.

Source: Environmental Protection Agency, Chesapeake Bay: A Profile of Environmental Change, Appendix C (Philadelphia, Pennsylvania: EPA, 1985).

As a result of high salinity and low SAV levels in the Bay, only species which do not require SAV for spawning and whose eggs and larvae have a high tolerance for salinity achieve optimal spawning success. Fish in this category include carp, silversides, pumpkinseed and killifish. Other species continue to reproduce but with diminished success. The Bay's remaining SAV beds still provide spawning habitat for SAV-dependent fresh water species, even though salinity levels are not optimal. Species found in the Bay which are dependent on SAV for spawning include yellow perch, chain pickerel, golden shiner and bluespotted sunfish. As mentioned previously, most of the Bay's SAV is found in the southeastern portion of the Bay in the vicinity of False Cape State Park.

Most of the fish species inhabiting the Back Bay nest and spawn in shallow areas along the shoreline. Fish nests are built in a variety of environments depending on the species. For example, catfish will usually nest in cavities such as hollow logs, overhanging edges or holes in mud banks. Most species of the sunfish family, which includes bluegill, bass and crappie, build colonies of nests in areas of sand or gravel. Most freshwater fish in Southeastern Virginia spawn between late winter and early summer when water temperatures are between 50°F and 75°F.

There is little information regarding the fisheries of the region's free-flowing rivers. The few studies that have been conducted indicate that these rivers may provide spawning habitat for as many as 50 to 75 resident species of freshwater and semi-anadromous fish. In addition, anadromous species including american shad, blueback herring and alewife, spawn in the Blackwater and Nottoway rivers. These three species plus the striped bass spawn in the Meherrin River.[12] A 1988 fish survey conducted in conjunction with the Southeastern Expressway project found that, although the North Landing River system contains suitable anadromous fish spawning habitat and small numbers of blueback herring are present, the River and its tributaries do not support Spring spawning runs.[13] Likewise, there is no evidence of anadromous fish spawning activity in the Virginia portion of the Northwest River. Table 2 describes common spawning habitat for anadromous and semi-anadromous species. As mentioned above, most species of resident freshwater fish spawn either in nests found along the immediate shoreline, or in SAV beds.

LAKES

Fish found in the region's 27 major lakes are non-migratory and depend on lake waters for their entire life cycles. Many of the region's lakes contain both indigenous species and species stocked by the Virginia Department of Game and Inland Fisheries. Nearly all of the freshwater species found in the region's lakes spawn in nests built along the shoreline. A few species such as yellow perch, pickerel, shiner, bluespotted sunfish and warmouth spawn in SAV beds.

[12] Hampton Roads Water Quality Management Plan, p. 92.

[13] James R. Reed and Associates, Southeastern Expressway Project Anadromous Fish Study Final Report: Spring Sampling, 1988, (Newport News, Virginia: James R. Rees and Associate, 1988).

NURSERY AREAS

MAJOR RECEIVING WATERS

The lower Chesapeake Bay, Hampton Roads and the lower James River are nursery areas for a number of estuarine and marine species of fish. The prime nursery areas of most species of anadromous and semi-anadromous fish are located in the upstream portions of the James outside of the Southeastern Virginia region. However, juvenile herring, alewife and shad may "overwinter" in the lower estuaries or the deep waters of the Bay before returning to the ocean.

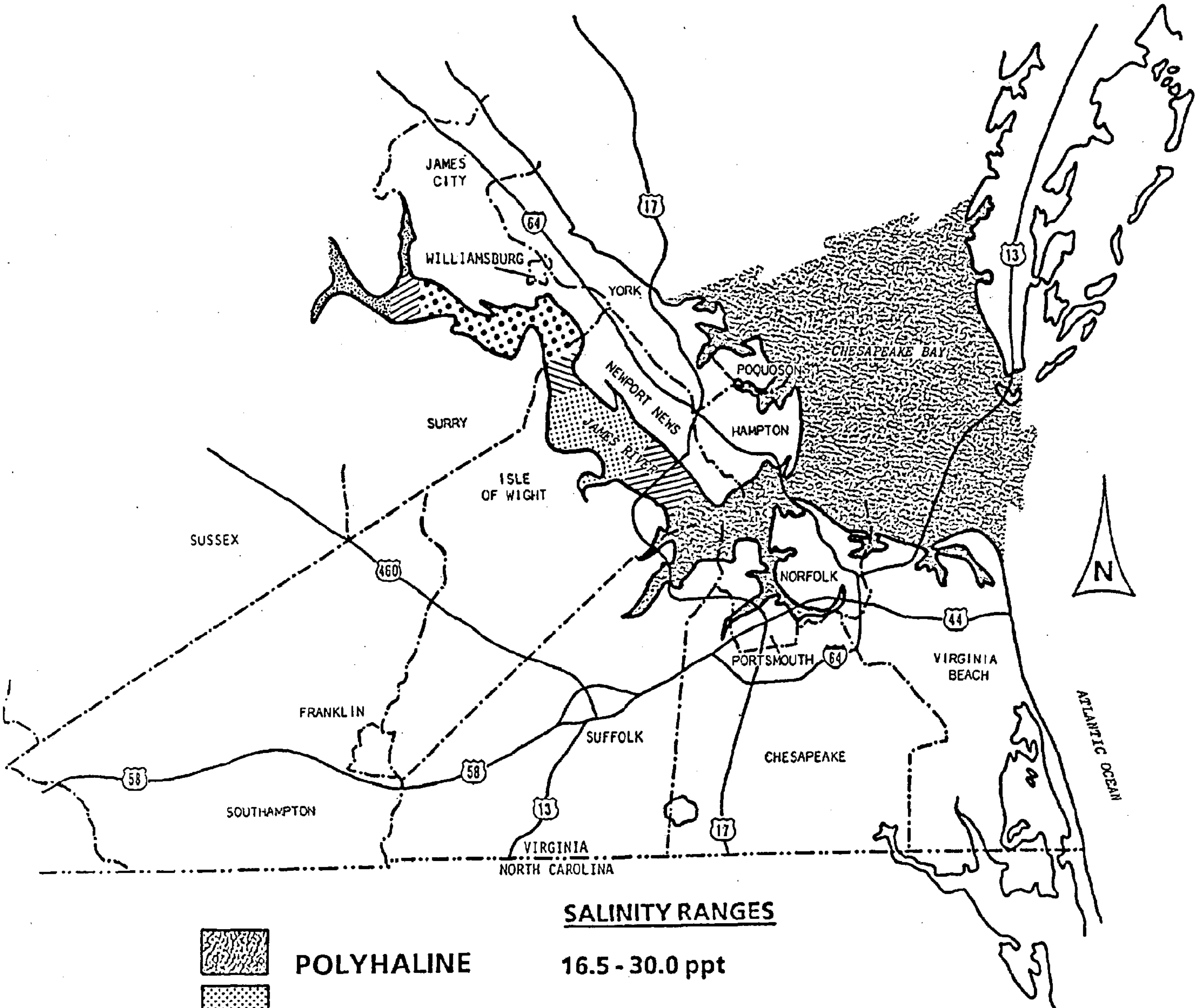
It is impossible to identify specific locations of estuarine and marine fish nurseries in the lower Chesapeake/Hampton Roads/lower James River area because schools of juveniles relocate frequently in response to a number of factors including salinity, temperature, time of day, food supply and oxygen levels. Also, the juveniles of many species migrate gradually downstream as they mature. In general, however, the nursery areas of most species are associated with certain ecological zones defined by salinity levels. These zones and their corresponding salinity ranges are as follows: polyhaline (16.5 - 30.0 ppt), mesohaline (3.0 - 16.5 ppt), oligohaline (0.5 - 3.0 ppt) and freshwater (less than 0.5 ppt). Figure 3 shows the approximate locations of these zones in the lower Chesapeake Bay, Hampton Roads and the lower James River. Salinity regimes migrate with the tides, freshwater inflow and weather conditions. Therefore, transition areas are also identified which may be dominated by either the contiguous upstream or downstream zone depending on the influence of these factors. Figure 3 is to be used with Table 3 to indicate approximately where the nursery areas of selected species of marine, estuarine, anadromous and semi-anadromous fish are located. For each of the selected species, Table 3 shows the ecological zone(s) in which nursery areas are located, general nursery habitat requirements, and a brief description of juvenile behavior characteristics.

TIDAL TRIBUTARIES

There is little information available regarding the extent to which the region's estuaries that are tributary to the lower Chesapeake Bay, Hampton Roads and the lower James River are used as fish nursery areas. During several fish surveys conducted between 1973 and 1974 in the Elizabeth River, a number of species of marine, estuarine, anadromous and semi-anadromous fish were taken, most of which were juveniles or young-of-the-year.[14] The results of these surveys are a strong indication that the Elizabeth River is used, at least to some degree, as a fish nursery. Given these findings, it might be reasonably assumed that other tidal estuaries in Southeastern Virginia are utilized as nurseries as well.

[14]U.S. Army Corps of Engineers, <u>Final Environmental Impact Report: Hampton Roads Energy Company's Portsmouth Refinery and Terminal, Portsmouth Virginia</u> (Norfolk, Virginia: COE, 1977).

FIGURE 3
ECOLOGICAL ZONES IN THE LOWER CHESAPEAKE BAY, HAMPTON ROADS AND THE LOWER JAMES RIVER



SALINITY RANGES

	POLYHALINE	16.5 - 30.0 ppt
	MESOHALINE	3.0 - 16.5 ppt
	OLIGOHALINE	0.5 - 3.0 ppt
	FRESHWATER	< 0.5 ppt
	TRANSITION ZONE	

PREPARED BY SVPDC 1989
SOURCE: Roberts, M.H., Jr. et al, The Chesapeake Bay: A Study of Present and Future Water Quality and its Ecological Effects, Volume II, (Gloucester Point, Virginia: VIMS).

TABLE 3

CHARACTERISTICS OF MARINE, ANADROMOUS AND SEMI-ANADROMOUS FISH NURSERY AREAS

Species	Ecological Zone(s)	Habitat Characteristics	Behavior
MARINE			
Atlantic Menhaden	Fresh-Mesohaline	Shallow water deeper than 1 meter, organic bottom sediments and high plankton productivity.	Remain in Bay during the summer. May leave in fall or overwinter in Bay.
Weakfish	Fresh-Polyhaline	Soft, muddy bottoms.	Move to low salinity areas for for the summer and migrate coast in the fallto the
Spotted Seatrout	Oligo-Polyhaline	Grassy, shallow water flats.	School and remain in nursery area until cold weather causes them to move to deeper water.
Spot	Meso-Polyhaline	Muddy bottoms deeper than 1 meter.	School along shore during the summer. Move downstream as they grow.
Atlantic Croaker	Oligo-Polyhaline	Channel waters deeper than 1 meter.	Move downstream as they grow and most leave the estuary in the fall. Some overwinter.
Bluefish	Fresh-Polyhaline	The greater the juvenile population, the further the penetration into the Bay.	Enter Bay in early summer and leave by late fall.
ESTUARINE			
Atlantic Silverside	Mesohaline	Vegetated bottom near shore.	Juveniles tend to remain in the same area in which they were spawned.
Blue Crab	Polyhaline	Depending on the stage of development, may be found in surface waters or on the bottom of the lower Bay.	Larvae are first swept to sea but juveniles return to the Bay in bottom waters and migrate to estuaries.

TABLE 3 (Continued)
CHARACTERISTICS OF MARINE, ANADROMOUS AND SEMI-ANADROMOUS FISH NURSERY AREAS

Species	Ecological Zone(s)	Habitat Characteristics	Behavior
ANADROMOUS			
Blueback Herring	Fresh-Oligohaline	Surface waters from shore to shore.	Migrate toward the ocean in the fall. May remain in lower Bay during first and second winter.
Alewife	Meso-Oligohaline	Depths of up to 3 meters from shore to shore.	Migrate toward the ocean in the fall. Some overwinter in deep areas of the Bay.
American Shad	Mesohaline	Depths greater than 3 meters from shore to shore.	Migrate toward the ocean in the fall. Some remain in the lower Bay during the winter.
Striped Bass	Oligo-Mesohaline	Shallow water with sandy or gravel bottom near shore.	Move downstream as they mature. Yearlings school in rivers or move into lower estuaries during the summer.
SEMI-ANADROMOUS			
Channel Catfish	Fresh-Mesohaline	Vegetation over muddy bottom.	Strong schooling tendencies during first year.
White Perch	Fresh-Oligohaline	Shallow (0-3 meters), sluggish water from shore to shore over silt, mud or vegetation. Move to sandy shoals at night.	May form large schools and remain in nursery area during first year.
Yellow Perch	Oligo-Mesohaline	Vegetated areas near shore.	Initially concentrate at surface and tend to form large schools.

Sources: U.S. Environmental Protection Agency, Chesapeake Bay: A Profile of Environmental Change (Appendices), (Philadelphia, Pennsylvania: EPA, 1983), pp. C-1 - C-33.

U.S. Army Corps of Engineers, Chesapeake Bay Low Freshwater Inflow Study: Appendix E - Biota, (Baltimore, Maryland: COE, 1984), pp. E-111 - E-123.

The ecological zones described in the previous section have not been delineated for the region's tidal tributaries. It is therefore difficult to identify even the general locations of nursery areas. Given the full range of salinities and estuarine habitats found in these tributaries, however, it can be assumed that most of the marine, estuarine, anadromous and semi-anadromous fish common to Southeastern Virginia use portions of these estuaries as nurseries. General nursery habitat requirements and juvenile behavior characteristics can be found in Table 3.

THE BACK BAY AND FREE-FLOWING RIVERS

The results of a fish survey conducted in the Back Bay during 1985 and 1986 indicate that the Bay's potential as a freshwater, anadromous and semi-anadromous fish nursery has severely declined due to increased salinity levels.[15] Although the Bay's salinity levels and habitat characteristics may still provide adequate nursery habitat for most of these species, high salinity levels have severely inhibited spawning success thus reducing juvenile populations. The Bay, however, has become a nursery area for many marine species which, because of the increased salinity, have migrated north from the Albemarle and Pamlico Sounds. The shift in the Back Bay from a freshwater/anadromous to a estuarine/marine fish nursery can be seen in a comparison of 1978 and 1986 fish survey data. Comparison of young-of-the-year (YOY) fish between 1978 and 1986 show an 81% decrease in freshwater YOY, a 12% increase in "fresh/brackish" YOY, and a 7,707% increase in "brackish/marine" YOY.[16] As mentioned in the previous section, the increase in Bay salinity was due to the pumping of saltwater from the ocean to stimulate the growth of SAV. The end of that project in 1987 and subsequent decreases in salinity levels revealed by recent testing may result in the reestablishment of spawning habitat that is more suitable for freshwater, anadromous and semi-anadromous species than for marine species.

The nursery habitat requirements of anadromous, semi-anadromous and marine species of fish using the Back Bay as a nursery can be found in Table 3. Freshwater fish nurseries in the Back Bay and the region's free flowing rivers are generally found in shallow water nests along the shoreline or in SAV beds.

Although several species of anadromous species use the Blackwater, Nottoway and Meherrin rivers for spawning, larvae are transported to nursery areas in more saline, downstream waters. Therefore, the nursery areas for these species are most likely located in the lower Chowan River or Albemarle Sound in North Carolina.

[15] Results of Back Bay Fish Population Sampling, 1985-1986.

[16] Ibid. p.2.

LAKES

As previously mentioned, most species of freshwater fish inhabiting the lakes of Southeastern Virginia spawn and nurse their young in shallow water nests along the shoreline or in SAV beds. The types of habitats required for nesting areas depend on the species of fish. The above section on spawning grounds discusses some of these habitat requirements.

SHELLFISH GROUNDS

MAJOR RECEIVING WATERS

The lower James River and Hampton Roads contain extensive oyster grounds. The lower Chesapeake Bay is too saline to support oysters, but does support some of the Bay's most productive clam grounds. About 25,000 acres of public oyster grounds, also known as Baylor Grounds, are located in the lower James River and Hampton Roads. About 10,000 of these acres are found within Southeastern Virginia (i.e., within the corporate limits of the localities comprising the Southeastern Virginia Planning District). Traditionally, the Baylor Grounds have been a major source of "seed oysters" which are grown for transplantation to other oyster beds in the Chesapeake Bay system. There are also approximately 1500 acres of privately leased shellfish grounds in the lower James River and Hampton Roads. Most of these grounds are not naturally productive and depend on the transplantation of seed oysters from the public grounds.

Some shellfish areas in the lower James River and Hampton Roads have been "condemned" by the State Division of Shellfish Sanitation (SDSS). This means that the taking of shellfish from these areas for direct marketing, seeding or purification is prohibited. The SDSS condemns shellfish areas when water quality standards for pathogenic microorganisms and other contaminants are exceeded. It also establishes automatic condemnation areas around marinas, public and private sewage treatment plants, and industrial discharges.

During recent years, the lower James River has become the state's principal source for mature oysters because two oyster diseases, MSX and dermo, have decimated oyster beds elsewhere. State harvest statistics for the 1987-88 season indicate that, of 300,000 bushels harvested statewide, 273,000 were taken from the James River and Hampton Roads.[17] Recently, MSX and dermo have begun infesting the oyster grounds in the James River/Hampton Roads area. It is anticipated that the 1989 harvest will be significantly lower than that of recent years.

The high salinity waters of the lower Chesapeake Bay contain a sizable portion of the state's 33,000 acres of public clamming grounds. There are no private clam ground leases. The SDSS has condemned clam grounds near the mouths of Little

[17] Lower James River Association, Lower James River Corridor Study, (LJRA, 1988), p.46.

Creek and the Elizabeth River because of pollutants emanating from these waterways.

Figure 4 shows the general locations of publicly and privately leased oyster grounds in Southeastern Virginia. Figure 5 shows locations of condemned shellfish areas throughout the region.

TIDAL TRIBUTARIES

Most of the shellfish grounds in the region's tidal tributaries are condemned. As of this writing, shellfish grounds remain open in the Nansemond River downstream of the King's Highway Bridge, in small areas near the mouths of Chuckatuck Creek and the Pagan River, and in Broad Bay in the Lynnhaven River system. Except for the Nansemond River, portions of these areas were condemned in the past, but reopened. Because of widely varying water quality conditions, including nonpoint source pollution, these areas will probably be subject to additional condemnations in the future.

Public oyster grounds and private leases are still delineated in the tidal tributaries. Given the magnitude of pollution problems and the large number of automatic condemnation areas, however, there is little likelihood that shellfish grounds in most of these water bodies will ever be reopened. The discharges that have resulted in the condemnation of the region's shellfish areas come from both point source and nonpoint sources. These sources include the discharges noted above which require automatic condemnation as well as animal feed lot discharges, leaking septic tanks and stormwater runoff.

Table 4 contains acreage totals for private leases, public grounds and condemned areas in each of the region'stributaries. Preparation of this table relied partially on 1979 data. Although there have been some changes to condemnation area boundaries since 1979, these changes are not considered to be large enough to significantly affect acreage totals. It should also be noted that a condemnation area does not necessarily contain privately leased or public grounds. In fact, it may not include shellfish beds. Condemnation areas are designated on the basis of water quality degradation, not the presence of shellfish beds. The general locations of private leases, public grounds and condemnation areas in the region's tidal tributaries are shown in Figures 4 and 5.

BACK BAY AND FREE-FLOWING RIVERS

There are no commercially important shellfish areas in these water bodies.

LAKES

There are no commercially important shellfish areas in these water bodies.

APPENDIX D

ESTIMATED ANNUAL NONPOINT SOURCE LOADINGS FOR WATERSHEDS AND THIRD-ORDER DRAINAGE BASINS

EXPLANATORY NOTES

The tables in this appendix show estimated nonpoint source loadings for developed and developing watersheds and third-order drainage basins in Southeastern Virginia. The following notes refer to these tables and the accompanying maps show the locations of the watersheds and third-order basins analyzed. The factors used to calculate the loadings estimates are found in Table 3 in the text.

1. For the purposes of this study, only those portions of the James River and Albemarle watersheds located in Southeastern Virginia were analyzed.

2. All loadings are expressed in pounds per year, except where otherwise noted.

3. The light industry land use acreage also includes all streets and highways.

4. BOD is 5-day Biochemical Oxygen Demand.

5. Total Suspended Solids (TSS) is expressed in thousands.

6. Fecal Coliform is expressed as 10^9 cells.

7. Total P = Total Phosphorus

8. Total N = Total Nitrogen

9. Fecal Coliform loading were not calculated for agricultural land use, and BOD, TSS and Fecal Coliform loadings were not calculated for water.

JAMES RIVER WATERSHED
ESTIMATED TOTAL ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL
BOD	607,589.63	427,360.88	155,733.75	613,490.86	244,504.68	1,454,841.81	175,898.42	0.00	3,679,420.03
TSS	4,776.24	3,273.82	1,193.01	4,757.01	1,717.59	116,387.34	1,241.64	0.00	133,346.66
FECAL COLIFORM	2,500,215.08	1,048,798.48	382,190.63	2,857,489.53	2,434,269.69	0.00	103,469.66	0.00	9,326,433.07
TOTAL P	24,855.94	16,859.19	6,143.63	24,605.25	9,025.79	33,623.01	5,173.48	14,342.87	134,629.16
TOTAL N	245,310.25	168,591.91	61,436.25	242,771.79	88,910.79	294,201.34	62,081.80	32,783.71	1,196,087.84
LEAD	35,253.20	34,698.57	12,644.44	7,873.68	4,512.90	1,293.19	2,069.39	409.80	98,755.16
ZINC	24,855.94	27,445.19	10,001.25	5,905.26	2,222.77	7,112.56	2,069.39	409.80	80,022.16
1985 LAND USE									
Acres:	16,245.71	19,603.71	7,143.75	32,807.00	6,735.67	32,329.82	103,469.66	20,489.82	238,893.23
Percent:	6.80%	8.21%	2.99%	13.73%	2.82%	13.53%	43.31%	8.58%	100.00%

JAMES RIVER DRAINAGE BASIN 1101 (Willoughby Bay)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	83,826.12	34,569.57	30,261.89	22,992.21	33,318.10	0.00	2,652.27	0.00	207,620.16	22.13
TSS	658.95	264.82	231.82	178.28	234.05	0.00	18.72	0.00	1,586.66	0.17
FECAL COLIFORM	344,942.23	84,838.16	74,266.56	107,092.06	331,712.44	0.00	1,560.16	0.00	944,411.60	100.66
TOTAL P	3,429.25	1,363.75	1,193.82	922.15	1,229.92	0.00	78.01	321.33	8,538.24	0.91
TOTAL N	33,844.23	13,637.54	11,938.18	9,098.52	12,115.67	0.00	936.10	734.48	82,304.72	8.77
LEAD	4,863.71	2,806.80	2,457.04	295.09	614.96	0.00	31.20	9.18	11,077.98	1.18
ZINC	3,429.25	2,220.06	1,943.42	221.32	302.89	0.00	31.20	9.18	8,157.33	0.87
1985 LAND USE										
Acres:	2,241.34	1,585.76	1,388.16	1,229.53	917.85	0.00	1,560.16	459.05	9,381.85	
Percent:	23.89%	16.90%	14.80%	13.11%	9.78%	0.00%	16.63%	4.89%	100.00%	

JAMES RIVER DRAINAGE BASIN 1201 (Elizabeth River - Lafayette R.)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	52,422.46	48,502.60	5,968.84	46,630.13	78,791.40	9.00	1,641.45	0.00	233,965.89	19.30
TSS	412.09	371.56	45.72	361.57	553.49	0.72	11.59	0.00	1,756.74	0.14
FECAL COLIFORM	215,717.01	119,031.61	14,648.30	217,191.69	784,441.11	0.00	965.56	0.00	1,351,995.28	111.52
TOTAL P	2,144.56	1,913.41	235.47	1,870.19	2,908.55	0.21	48.28	1,814.86	10,935.52	0.90
TOTAL N	21,165.22	19,134.05	2,354.68	18,452.57	28,651.42	1.82	579.34	4,148.26	94,487.35	7.79
LEAD	3,041.62	3,938.06	484.63	598.46	1,454.28	0.01	19.31	51.85	9,588.22	0.79
ZINC	2,144.56	3,114.85	383.32	448.85	716.29	0.04	19.31	51.85	6,879.06	0.57
1985 LAND USE										
Acres:	1,401.67	2,224.89	273.80	2,493.59	2,170.56	0.20	965.56	2,592.66	12,122.93	
Percent:	11.56%	18.35%	2.26%	20.57%	17.90%	0.00%	7.96%	21.39%	100.00%	

JAMES RIVER DRAINAGE BASIN 1202 (Elizabeth River - Eastern Br.)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	162,017.66	93,395.12	28,547.97	135,800.90	60,397.94	14,463.45	8,414.78	0.00	503,037.82	18.71
TSS	1,273.61	715.46	218.69	1,053.00	424.28	1,157.08	59.40	0.00	4,901.53	0.18
FECAL COLIFORM	666,698.34	229,203.63	70,060.39	632,527.17	601,317.20	0.00	4,949.87	0.00	2,204,756.59	82.01
TOTAL P	6,628.00	3,684.39	1,126.20	5,446.56	2,229.57	334.27	247.49	1,931.61	21,628.09	0.80
TOTAL N	65,413.55	36,843.95	11,262.04	53,739.39	21,962.89	2,924.83	2,969.92	4,415.12	199,531.69	7.42
LEAD	9,400.49	7,583.00	2,317.89	1,742.90	1,114.78	12.86	99.00	55.19	22,326.10	0.83
ZINC	6,628.00	5,997.85	1,833.36	1,307.17	549.07	70.71	99.00	55.19	16,540.35	0.62
1985 LAND USE										
Acres:	4,332.02	4,284.18	1,309.54	7,262.08	1,663.86	321.41	4,949.87	2,759.45	26,882.41	
Percent:	16.11%	15.94%	4.87%	27.01%	6.19%	1.20%	18.41%	10.26%	100.00%	

JAMES RIVER DRAINAGE BASIN 1203 (Elizabeth River - Southern Br.)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	132,359.31	110,920.14	75,104.27	176,667.02	41,258.40	177,570.81	55,720.97	0.00	769,600.92	12.43
TSS	1,040.47	849.71	575.34	1,369.88	289.83	14,205.66	393.32	0.00	18,724.22	0.30
FECAL COLIFORM	544,655.02	272,212.28	184,315.53	822,871.50	410,765.43	0.00	32,777.04	0.00	2,267,596.80	36.62
TOTAL P	5,414.70	4,375.75	2,962.83	7,085.58	1,523.04	4,103.66	1,638.85	1,775.94	28,880.54	0.47
TOTAL N	53,439.19	43,757.49	29,628.29	69,911.01	15,003.05	35,908.76	19,666.22	4,059.28	271,373.30	4.38
LEAD	7,679.67	9,005.90	6,097.92	2,267.38	761.52	157.84	655.54	50.74	26,676.51	0.43
ZINC	5,414.70	7,123.31	4,823.21	1,700.54	375.08	868.12	655.54	50.74	21,011.24	0.34
1985 LAND USE										
Acres:	3,539.02	5,088.08	3,445.15	9,447.43	1,136.60	3,946.02	32,777.04	2,537.05	61,916.39	
Percent:	5.72%	8.22%	5.56%	15.26%	1.84%	6.37%	52.94%	4.10%	100.00%	

JAMES RIVER DRAINAGE BASIN 1204 (Elizabeth River - Western Br.)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	55,935.59	58,935.65	15,363.55	138,771.47	14,296.39	241,416.90	20,425.04	0.00	545,144.58	16.75
TSS	439.71	451.48	117.69	1,076.04	100.43	19,313.35	144.18	0.00	21,642.87	0.66
FECAL COLIFORM	230,173.46	144,635.65	37,704.13	646,363.35	142,333.78	0.00	12,014.73	0.00	1,213,225.08	37.27
TOTAL P	2,288.27	2,324.98	606.09	5,565.70	527.75	5,579.41	600.74	1,671.01	19,163.95	0.59
TOTAL N	22,583.62	23,249.84	6,060.85	54,914.91	5,198.69	48,819.86	7,208.84	3,819.46	171,856.07	5.28
LEAD	3,245.46	4,785.14	1,247.41	1,781.02	263.87	214.59	240.29	47.74	11,825.54	0.36
ZINC	2,288.27	3,784.86	986.65	1,335.77	129.97	1,180.26	240.29	47.74	9,993.82	0.31
1985 LAND USE										
Acres:	1,495.60	2,703.47	704.75	7,420.93	393.84	5,364.82	12,014.73	2,387.16	32,553.41	
Percent:	4.59%	8.30%	2.16%	22.80%	1.21%	16.48%	36.91%	7.33%	100.00%	

JAMES RIVER DRAINAGE BASIN 1205 (Elizabeth River - Craney Island)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	37,680.13	1,715.88	487.23	8,868.10	199.65	0.00	5,845.84	0.00	54,796.83	5.50
TSS	296.20	13.14	3.73	68.76	1.40	0.00	41.26	0.00	424.51	0.04
FECAL COLIFORM	155,052.71	4,210.99	1,195.73	41,305.43	1,987.70	0.00	3,438.73	0.00	207,191.28	20.81
TOTAL P	1,541.46	67.69	19.22	355.67	7.37	0.00	171.94	3,450.86	5,614.21	0.56
TOTAL N	15,213.10	676.91	192.21	3,509.30	72.60	0.00	2,063.24	7,887.68	29,615.04	2.97
LEAD	2,186.25	139.32	39.56	113.82	3.69	0.00	68.77	98.60	2,650.00	0.27
ZINC	1,541.46	110.19	31.29	85.36	1.82	0.00	68.77	98.60	1,937.49	0.19
1985 LAND USE										
Acres:	1,007.49	78.71	22.35	474.23	5.50	0.00	3,438.73	4,929.80	9,956.81	
Percent:	10.12%	0.79%	0.22%	4.76%	0.06%	0.00%	34.54%	49.51%	100.00%	

JAMES RIVER DRAINAGE BASIN 1301 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	25,120.68	6,832.77	0.00	11,761.55	132.86	48,918.15	5,956.41	0.00	98,722.43	13.64
TSS	197.47	52.34	0.00	91.20	0.93	3,913.45	42.05	0.00	4,297.45	0.59
FECAL COLIFORM	103,370.94	16,768.51	0.00	54,782.42	1,322.72	0.00	3,503.77	0.00	179,748.35	24.84
TOTAL P	1,027.66	269.55	0.00	471.72	4.90	1,130.55	175.19	719.73	3,799.31	0.53
TOTAL N	10,142.31	2,695.50	0.00	4,654.30	48.31	9,892.34	2,102.26	1,645.09	31,180.11	4.31
LEAD	1,457.54	554.77	0.00	150.95	2.45	43.48	70.08	20.56	2,299.83	0.32
ZINC	1,027.66	438.80	0.00	113.21	1.21	239.16	70.08	20.56	1,910.68	0.26
1985 LAND USE										
Acres:	671.68	313.43	0.00	628.96	3.66	1,087.07	3,503.77	1,028.18	7,236.75	
Percent:	9.28%	4.33%	0.00%	8.69%	0.05%	15.02%	48.42%	14.21%	100.00%	

JAMES RIVER DRAINAGE BASIN 1302 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	3,850.70	3,915.28	0.00	5,597.10	8.71	29,909.25	5,577.34	0.00	48,858.39	9.88
TSS	30.27	29.99	0.00	43.40	0.06	2,392.74	39.37	0.00	2,535.83	0.51
FECAL COLIFORM	15,845.54	9,608.60	0.00	26,069.90	86.74	0.00	3,280.79	0.00	54,891.57	11.10
TOTAL P	157.53	154.46	0.00	224.48	0.32	691.24	164.04	291.86	1,683.92	0.34
TOTAL N	1,554.70	1,544.56	0.00	2,214.89	3.17	6,048.32	1,968.47	667.10	14,001.21	2.83
LEAD	223.42	317.89	0.00	71.83	0.16	26.59	65.62	8.34	713.85	0.14
ZINC	157.53	251.44	0.00	53.88	0.08	146.22	65.62	8.34	683.10	0.14
1985 LAND USE										
Acres:	102.96	179.60	0.00	299.31	0.24	664.65	3,280.79	416.94	4,944.49	
Percent:	2.08%	3.63%	0.00%	6.05%	0.00%	13.44%	66.35%	8.43%	100.00%	

JAMES RIVER DRAINAGE BASIN 1303 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	20,243.87	5,493.16	0.00	1,901.23	78.41	68,216.85	6,490.50	0.00	102,424.02	15.95
TSS	159.14	42.08	0.00	14.74	0.55	5,457.35	45.82	0.00	5,719.67	0.89
FECAL COLIFORM	83,302.99	13,480.93	0.00	8,855.46	780.62	0.00	3,817.94	0.00	110,237.94	17.16
TOTAL P	828.16	216.70	0.00	76.25	2.89	1,576.57	190.90	133.92	3,025.40	0.47
TOTAL N	8,173.33	2,167.03	0.00	752.36	28.51	13,794.96	2,290.76	306.11	27,513.07	4.28
LEAD	1,174.58	446.00	0.00	24.40	1.45	60.64	76.36	3.83	1,787.25	0.28
ZINC	828.16	352.77	0.00	18.30	0.71	333.50	76.36	3.83	1,613.63	0.25
1985 LAND USE										
Acres:	541.28	251.98	0.00	101.67	2.16	1,515.93	3,817.94	191.32	6,422.28	
Percent:	8.43%	3.92%	0.00%	1.58%	0.03%	23.60%	59.45%	2.98%	100.00%	

JAMES RIVER DRAINAGE BASIN 1304 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	1,385.30	6,570.08	0.00	2,139.09	0.00	110,127.60	7,483.40	0.00	127,705.47	17.46
TSS	10.89	50.33	0.00	16.59	0.00	8,810.21	52.82	0.00	8,940.84	1.22
FECAL COLIFORM	5,700.46	16,123.83	0.00	9,963.37	0.00	0.00	4,402.00	0.00	36,189.66	4.95
TOTAL P	56.67	259.19	0.00	85.79	0.00	2,545.17	220.10	9.08	3,176.00	0.43
TOTAL N	559.30	2,591.87	0.00	846.49	0.00	22,270.25	2,641.20	20.75	28,929.86	3.95
LEAD	80.38	533.44	0.00	27.45	0.00	97.89	88.04	0.26	827.46	0.11
ZINC	56.67	421.93	0.00	20.59	0.00	538.40	88.04	0.26	1,125.89	0.15
1985 LAND USE										
Acres:	37.04	301.38	0.00	114.39	0.00	2,447.28	4,402.00	12.97	7,315.06	
Percent:	0.51%	4.12%	0.00%	1.56%	0.00%	33.46%	60.18%	0.18%	100.00%	

JAMES RIVER DRAINAGE BASIN 1305 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	582.69	1,527.74	0.00	5,864.51	0.00	52,408.35	5,382.01	0.00	65,765.31	11.72
TSS	4.58	11.70	0.00	45.47	0.00	4,192.67	37.99	0.00	4,292.42	0.77
FECAL COLIFORM	2,397.76	3,749.28	0.00	27,315.43	0.00	0.00	3,165.89	0.00	36,628.36	6.53
TOTAL P	23.84	60.27	0.00	235.21	0.00	1,211.22	158.29	616.28	2,305.10	0.41
TOTAL N	235.26	602.69	0.00	2,320.71	0.00	10,598.13	1,899.53	1,408.64	17,064.97	3.04
LEAD	33.81	124.04	0.00	75.27	0.00	46.59	63.32	17.61	360.63	0.06
ZINC	23.84	98.11	0.00	56.45	0.00	256.22	63.32	17.61	515.54	0.09
1985 LAND USE										
Acres:	15.58	70.08	0.00	313.61	0.00	1,164.63	3,165.89	880.40	5,610.19	
Percent:	0.28%	1.25%	0.00%	5.59%	0.00%	20.76%	56.43%	15.69%	100.00%	

JAMES RIVER DRAINAGE BASIN 1306 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	1,070.01	5,161.37	0.00	4,497.91	0.00	36,496.35	5,958.69	0.00	53,184.33	10.80
TSS	8.41	39.54	0.00	34.88	0.00	2,919.71	42.06	0.00	3,044.60	0.62
FECAL COLIFORM	4,403.08	12,666.66	0.00	20,950.16	0.00	0.00	3,505.11	0.00	41,525.01	8.44
TOTAL P	43.77	203.61	0.00	180.40	0.00	843.47	175.26	70.55	1,517.06	0.31
TOTAL N	432.01	2,036.14	0.00	1,779.92	0.00	7,380.37	2,103.07	161.25	13,892.76	2.82
LEAD	62.08	419.07	0.00	57.73	0.00	32.44	70.10	2.02	643.44	0.13
ZINC	43.77	331.46	0.00	43.30	0.00	178.43	70.10	2.02	669.08	0.14
1985 LAND USE										
Acres:	28.61	236.76	0.00	240.53	0.00	811.03	3,505.11	100.78	4,922.82	
Percent:	0.58%	4.81%	0.00%	4.89%	0.00%	16.47%	71.20%	2.05%	100.00%	

JAMES RIVER DRAINAGE BASIN 1307 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	9,793.56	11,875.77	0.00	13,063.63	0.00	324,698.85	19,156.94	0.00	378,588.76	18.17
TSS	76.99	90.97	0.00	101.30	0.00	25,975.91	135.23	0.00	26,380.39	1.27
FECAL COLIFORM	40,300.25	29,144.66	0.00	60,847.19	0.00	0.00	11,268.79	0.00	141,560.89	6.79
TOTAL P	400.65	468.49	0.00	523.94	0.00	7,504.15	563.44	595.22	10,055.89	0.48
TOTAL N	3,954.09	4,684.94	0.00	5,169.57	0.00	65,661.32	6,761.27	1,360.50	87,591.68	4.20
LEAD	568.24	964.23	0.00	167.66	0.00	288.62	225.38	17.01	2,231.13	0.11
ZINC	400.65	762.66	0.00	125.75	0.00	1,587.42	225.38	17.01	3,118.85	0.15
1985 LAND USE										
Acres:	261.86	544.76	0.00	698.59	0.00	7,215.53	11,268.79	850.31	20,839.84	
Percent:	1.26%	2.61%	0.00%	3.35%	0.00%	34.62%	54.07%	4.08%	100.00%	

JAMES RIVER DRAINAGE BASIN 1308 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	9,145.05	16,066.16	0.00	11,084.61	11,043.19	44,338.95	2,480.10	0.00	94,158.06	21.67
TSS	71.89	123.08	0.00	85.95	77.58	3,547.12	17.51	0.00	3,923.11	0.90
FECAL COLIFORM	37,631.63	39,428.43	0.00	51,629.40	109,945.11	0.00	1,458.88	0.00	240,093.44	55.26
TOTAL P	374.12	633.80	0.00	444.57	407.65	1,024.72	72.94	15.71	2,973.52	0.68
TOTAL N	3,692.25	6,338.03	0.00	4,386.42	4,015.70	8,966.32	875.33	35.90	28,309.96	6.52
LEAD	530.61	1,304.45	0.00	142.26	203.83	39.41	29.18	0.45	2,250.19	0.52
ZINC	374.12	1,031.77	0.00	106.70	100.39	216.77	29.18	0.45	1,859.37	0.43
1985 LAND USE										
Acres:	244.52	736.98	0.00	592.76	304.22	985.31	1,458.88	22.44	4,345.11	
Percent:	5.63%	16.96%	0.00%	13.64%	7.00%	22.68%	33.58%	0.52%	100.00%	

JAMES RIVER DRAINAGE BASIN 1309 (Nansemond River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	11,800.45	17,037.35	0.00	21,287.89	4,979.63	203,137.65	16,941.16	0.00	275,184.14	16.08
TSS	92.76	130.52	0.00	165.07	34.98	16,251.01	119.58	0.00	16,793.92	0.98
FECAL COLIFORM	48,558.53	41,811.85	0.00	99,153.77	49,576.85	0.00	9,965.39	0.00	249,066.39	14.56
TOTAL P	482.75	672.12	0.00	853.79	183.82	4,694.74	498.27	180.61	7,568.09	0.44
TOTAL N	4,764.35	6,721.16	0.00	8,424.09	1,810.78	41,078.95	5,979.23	412.82	69,191.37	4.04
LEAD	684.68	1,383.31	0.00	273.21	91.91	180.57	199.31	5.16	2,818.15	0.16
ZINC	482.75	1,094.14	0.00	204.91	45.27	993.12	199.31	5.16	3,024.65	0.18
1985 LAND USE										
Acres:	315.52	781.53	0.00	1,138.39	137.18	4,514.17	9,965.39	258.01	17,110.19	
Percent:	1.84%	4.57%	0.00%	6.65%	0.80%	26.38%	58.24%	1.51%	100.00%	

JAMES RIVER DRAINAGE BASIN 1403 (Chuckatuck Creek)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	0.00	43.16	0.00	215.05	0.00	9,379.80	432.07	0.00	10,070.09	19.98
TSS	0.00	0.33	0.00	1.67	0.00	750.38	3.05	0.00	755.43	1.50
FECAL COLIFORM	0.00	105.93	0.00	1,001.65	0.00	0.00	254.16	0.00	1,361.74	2.70
TOTAL P	0.00	1.70	0.00	8.63	0.00	216.78	12.71	19.57	259.39	0.51
TOTAL N	0.00	17.03	0.00	85.10	0.00	1,896.80	152.50	44.74	2,196.16	4.36
LEAD	0.00	3.50	0.00	2.76	0.00	8.34	5.08	0.56	20.24	0.04
ZINC	0.00	2.77	0.00	2.07	0.00	45.86	5.08	0.56	56.34	0.11
1985 LAND USE										
Acres:	0.00	1.98	0.00	11.50	0.00	208.44	254.16	27.96	504.04	
Percent:	0.00%	0.39%	0.00%	2.28%	0.00%	41.35%	50.42%	5.55%	100.00%	

JAMES RIVER DRAINAGE BASIN 1404 (Chuckatuck Creek)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	356.05	4,799.05	0.00	6,348.46	0.00	93,749.85	5,339.45	0.00	110,592.86	16.20
TSS	2.80	36.76	0.00	49.23	0.00	7,499.99	37.69	0.00	7,626.47	1.12
FECAL COLIFORM	1,465.13	11,777.49	0.00	29,569.58	0.00	0.00	3,140.85	0.00	45,953.05	6.73
TOTAL P	14.57	189.32	0.00	254.62	0.00	2,166.66	157.04	724.74	3,506.95	0.51
TOTAL N	143.75	1,893.20	0.00	2,512.23	0.00	18,958.30	1,884.51	1,656.54	27,048.54	3.96
LEAD	20.66	389.65	0.00	81.48	0.00	83.33	62.82	20.71	658.64	0.10
ZINC	14.57	308.20	0.00	61.11	0.00	458.33	62.82	20.71	925.73	0.14
1985 LAND USE										
Acres:	9.52	220.14	0.00	339.49	0.00	2,083.33	3,140.85	1,035.34	6,828.67	
Percent:	0.14%	3.22%	0.00%	4.97%	0.00%	30.51%	46.00%	15.16%	100.00%	

JAMES RIVER DRAINAGE BASIN 1501 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	175.78	74.12	647.02	0.00	40,738.50	1,980.67	0.00	43,616.09	17.66
TSS	1.38	0.57	5.02	0.00	3,259.00	13.98	0.00	3,279.95	1.33
Fecal Coliform	723.33	181.90	3,013.66	0.00	0.00	1,163.90	0.00	5,082.79	2.04
Total P	7.19	2.92	25.95	0.00	941.51	58.26	249.76	1,285.59	0.52
Total N	70.97	29.24	256.04	0.00	8,238.23	699.06	570.88	9,864.42	4.00
Lead	10.20	6.02	8.30	0.00	36.21	23.30	7.14	91.17	0.04
Zinc	7.19	4.76	6.23	0.00	199.17	23.30	7.14	247.79	0.10
1985 LAND USE									
Acres:	4.70	3.40	34.60	0.00	905.30	1,165.10	356.80	2,469.90	
Percent:	0.20	0.10	1.40	0.00	36.70	47.20	14.40	100.0	

JAMES RIVER DRAINAGE BASIN 1502 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	1,690.48	1,151.04	3,289.33	0.00	30,397.50	1,507.05	0.00	38,035.40	17.96
TSS	13.29	8.82	25.50	0.00	2,431.80	10.64	0.00	2,490.05	1.18
Fecal Coliform	6,956.28	2,824.80	15,320.89	0.00	0.00	886.50	0.00	25,988.47	12.27
Total P	69.16	45.41	131.93	0.00	702.52	44.33	197.26	1,190.61	0.56
Total N	682.52	454.08	1,301.66	0.00	6,147.05	531.90	450.88	9,568.09	4.52
Lead	98.08	93.46	39.17	0.00	27.02	17.73	5.64	281.10	0.13
Zinc	69.16	73.92	29.38	0.00	148.61	17.73	5.64	344.44	0.16
1985 LAND USE									
Acres:	45.20	52.80	175.90	0.00	675.50	886.50	281.80	2,117.70	
Percent:	2.10	2.50	8.30	0.00	31.90	41.90	13.30	100.00	

JAMES RIVER DRAINAGE BASIN 1503 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	6,488.90	1,360.32	5,020.95	373.89	92,277.00	6,383.50	0.00	111,904.56	16.66
TSS	51.01	10.42	38.93	2.63	7,382.16	45.06	0.00	7,530.21	1.12
Fecal Coliform	26,701.65	3,338.40	23,386.35	3,722.42	0.00	3,755.00	0.00	57,903.82	8.62
Total P	265.46	53.66	201.38	13.80	2,132.62	187.75	278.88	3,133.55	0.47
Total N	2,619.85	536.64	1,986.90	135.96	18,660.46	2,253.00	637.44	26,830.25	4.00
Lead	376.50	110.45	64.44	6.90	82.02	75.10	7.97	723.38	0.11
Zinc	265.46	87.36	48.33	3.40	451.13	75.10	7.97	938.75	0.14
1985 LAND USE									
Acres:	173.50	62.40	268.50	10.30	2,050.60	3,755.00	398.40	6,718.70	
Percent:	2.60	0.90	4.00	0.20	30.50	55.90	5.90	100.00	

JAMES RIVER DRAINAGE BASIN 1504 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	4,390.76	5,162.24	16,502.75	1,045.44	295,348.50	18,943.10	0.00	341,392.79	17.92
TSS	34.52	39.55	127.96	7.34	23,627.88	133.72	0.00	23,970.97	1.23
Fecal Coliform	18,067.86	12,668.80	76,865.75	10,408.32	0.00	6,563.30	0.00	124,574.03	6.54
Total P	179.62	203.65	661.88	38.59	6,825.83	557.15	53.62	8,520.34	0.45
Total N	1,772.74	2,036.48	6,530.50	380.16	59,726.03	6,685.80	122.56	77,254.27	4.06
Lead	254.76	355.24	195.74	19.30	262.53	222.86	1.53	1,311.96	0.07
Zinc	174.57	280.98	158.85	9.50	1,443.93	222.86	1.53	2,292.22	0.12
1985 LAND USE									
Acres:	114.10	200.70	882.50	28.80	6,563.30	11,143.00	76.60	19,048.40	
Percent:	0.60	1.10	4.60	0.20	34.50	58.50	0.40	100.00	

JAMES RIVER DRAINAGE BASIN 1505 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	486.20	329.18	647.02	0.00	41,305.50	1,993.25	0.00	44,761.15	17.80
TSS	3.82	2.52	5.02	0.00	3,304.44	14.07	0.00	3,329.87	1.32
Fecal Coliform	2,007.70	807.85	3,013.66	0.00	0.00	1,172.50	0.00	7,001.71	2.78
Total P	19.89	12.99	25.95	0.00	954.62	58.63	253.26	1,325.34	0.53
Total N	196.30	129.86	256.04	0.00	8,352.89	703.50	578.88	10,217.47	4.06
Lead	28.21	26.73	8.30	0.00	36.72	23.45	7.24	130.65	0.05
Zinc	19.89	21.14	6.23	0.00	201.94	23.45	7.24	279.89	0.11
1985 LAND USE									
Acres:	13.00	15.10	34.60	0.00	917.90	1,172.50	361.80	2,514.90	
Percent:	0.50	0.60	1.40	0.00	36.50	46.60	14.40	100.00	

JAMES RIVER DRAINAGE BASIN 1506 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	1,926.10	2,057.92	2,311.32	410.19	72,306.00	5,234.98	0.00	84,246.51	16.29
TSS	15.14	15.76	17.92	2.88	5,784.48	36.95	0.00	5,873.13	1.14
Fecal Coliform	7,925.50	5,050.40	10,765.56	4,083.82	0.00	3,079.40	0.00	30,904.68	5.98
Total P	78.80	81.18	92.70	15.14	1,671.07	153.97	143.50	2,206.36	0.43
Total N	700.64	811.84	914.64	149.16	14,621.88	1,847.64	8,275.20	27,321.00	5.28
Lead	111.76	167.09	29.66	7.57	64.27	61.59	4.10	446.04	0.09
Zinc	78.80	132.16	22.25	3.73	353.50	61.59	4.10	656.13	0.13
1985 LAND USE									
Acres:	51.50	94.40	123.60	11.30	1,606.80	3,079.40	205.00	5,172.00	
Percent:	1.00	1.80	2.40	0.20	31.10	59.50	4.00	100.00	

JAMES RIVER DRAINAGE BASIN 1507 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	56.10	89.38	600.27	18.15	13,788.00	1,631.49	0.00	16,183.39	12.33
TSS	0.44	0.68	4.65	0.13	1,103.04	11.52	0.00	1,120.46	0.85
Fecal Coliform	230.85	219.35	2,795.91	180.70	0.00	959.70	0.00	4,386.51	3.34
Total P	2.30	3.53	24.10	0.67	318.66	47.99	5.60	402.85	0.31
Total N	22.65	35.26	237.54	6.60	2,788.24	575.82	12.80	3,678.91	2.80
Lead	3.26	7.26	7.70	0.34	12.26	19.19	0.16	50.17	0.04
Zinc	2.30	5.74	5.78	0.17	67.41	19.19	0.16	100.75	0.08
1985 LAND USE									
Acres:	1.50	4.10	32.10	0.50	306.40	959.70	8.00	1,312.30	
Percent:	0.10	0.30	2.40	0.04	23.30	73.10	0.60	100.00	

JAMES RIVER DRAINAGE BASIN 1508 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	82.28	398.94	1,421.20	32.67	41,656.50	2,764.54	0.00	46,356.13	17.35
TSS	0.65	3.06	11.02	0.23	3,332.52	19.51	0.00	3,366.99	1.26
Fecal Coliform	338.58	979.05	6,619.60	361.40	0.00	1,626.20	0.00	9,924.83	3.71
Total P	3.37	15.74	57.00	1.21	962.73	81.31	15.82	1,137.18	0.43
Total N	33.22	157.38	562.40	14.52	8,423.87	975.72	36.16	10,203.27	3.82
Lead	4.77	32.39	18.24	0.74	37.28	32.52	0.45	126.14	0.05
Zinc	3.34	25.62	13.68	0.36	203.65	32.52	0.45	279.62	0.10
1985 LAND USE									
Acres:	2.20	18.30	76.00	1.10	925.70	1,626.20	22.60	2,671.90	
Percent:	0.10	0.70	2.80	0.04	34.60	60.90	0.80	100.00	

JAMES RIVER DRAINAGE BASIN 1509 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	78.54	470.88	1,494.13	32.67	46,345.50	2,598.10	0.00	51,019.82	18.98
TSS	0.62	3.61	11.59	0.23	3,707.64	18.34	0.00	3,742.03	1.39
Fecal Coliform	323.19	1,155.60	6,959.29	325.26	0.00	1,528.30	0.00	9,251.64	3.44
Total P	3.21	18.58	59.93	1.21	1,071.10	76.42	17.36	1,247.81	0.46
Total N	31.71	185.76	591.26	11.88	9,372.09	916.98	396.80	11,506.48	4.28
Lead	4.56	38.23	19.18	0.60	41.20	30.57	0.50	134.84	0.05
Zinc	3.21	30.24	14.38	0.30	226.58	30.57	0.50	305.78	0.11
1985 LAND USE									
Acres:	2.10	21.60	79.90	0.90	1,029.90	1,528.30	24.80	2,687.50	
Percent:	0.10	0.80	3.00	0.03	38.30	56.90	0.90	100.00	

JAMES RIVER DRAINAGE BASIN 1510 (Pagan River)
ESTIMATED ANNUAL NPS LOADS

Parameter	Commercial/ Institutional	Industry/ Streets	Low Density Residential	High Density Residential	Agricultural	Open and Undeveloped	Water	Total	Pounds Per Acre
BOD	4,319.70	974.46	2,361.81	36.30	31,387.50	2,878.44	0.00	41,958.21	15.52
TSS	33.96	7.46	18.31	0.26	2,511.00	20.32	0.00	2,591.31	0.96
Fecal Coliform	17,775.45	2,391.45	159,741.40	361.40	0.00	1,693.20	0.00	181,962.90	67.33
Total P	176.15	38.44	94.73	1.34	725.40	84.66	0.70	1,121.42	0.41
Total N	1,744.05	384.42	934.62	13.20	6,347.25	1,015.92	39.20	10,478.66	3.88
Lead	250.35	79.12	30.12	0.67	27.90	33.86	0.50	422.52	0.16
Zinc	176.72	62.58	22.73	0.33	153.46	33.86	0.50	450.18	0.16
1985 LAND USE									
Acres:	115.50	44.70	126.30	1.00	697.50	1,693.20	24.50	2,702.70	
Percent:	4.30	1.70	4.70	0.04	25.80	62.60	0.90	100.00	

LITTLE CREEK/LYNNHAVEN WATERSHED
ESTIMATED TOTAL ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL
BOD	141,801.17	206,100.03	0.00	285,744.98	160,467.20	127,582.20	32,793.88	0.00	954,489.46
TSS	1,114.69	1,578.84	0.00	2,215.67	1,127.25	10,206.58	231.49	0.00	16,474.51
FECAL COLIFORM	583,508.00	505,795.95	0.00	1,330,929.81	1,597,599.06	0.00	19,290.52	0.00	4,037,123.34
TOTAL P	5,800.96	8,130.55	0.00	11,460.36	5,923.58	2,948.57	964.53	5,032.20	40,260.75
TOTAL N	57,251.27	81,305.52	0.00	113,075.55	58,351.71	25,799.96	11,574.31	11,502.18	358,860.50
LEAD	8,227.50	16,733.81	0.00	3,667.32	2,961.79	113.41	385.81	143.78	32,233.41
ZINC	5,800.96	13,235.78	0.00	2,750.49	1,458.79	623.74	385.81	143.78	24,399.34
1985 LAND USE									
Acres:	3,791.48	9,454.13	0.00	15,280.48	4,420.58	2,835.16	19,290.52	7,188.86	62,275.31
Percent:	6.09%	15.18%	0.00%	24.54%	7.10%	4.55%	30.98%	11.54%	100.00%

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2101 (Lynnhaven - Broad Bay/Linkhorn Bay)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	22,546.22	32,661.63	0.00	52,994.30	37,130.18	19,900.80	12,181.27	0.00	177,414.40	11.48
TSS	177.23	250.21	0.00	410.92	260.83	1,592.06	85.99	0.00	2,777.24	0.18
FECAL COLIFORM	92,777.08	80,155.84	0.00	246,834.43	369,665.22	0.00	7,165.45	0.00	796,598.02	51.54
TOTAL P	922.35	1,288.49	0.00	2,125.44	1,370.65	459.93	358.27	1,324.16	7,849.28	0.51
TOTAL N	9,102.88	12,884.86	0.00	20,971.01	13,501.88	4,024.38	4,299.27	3,026.66	67,810.95	4.39
LEAD	1,308.16	2,651.68	0.00	680.14	685.32	17.69	143.31	37.83	5,524.34	0.36
ZINC	922.35	2,097.54	0.00	510.11	337.55	97.29	143.31	37.83	4,145.97	0.27
1985 LAND USE										
Acres:	602.84	1,498.24	0.00	2,833.92	1,022.87	442.24	7,165.45	1,891.66	15,457.22	
Percent:	3.90%	9.69%	0.00%	18.33%	6.62%	2.86%	46.36%	12.24%	100.00%	

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2102 (Lynnhaven - Eastern Br.)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	34,157.61	55,307.91	0.00	70,382.13	32,492.86	34,814.70	8,617.33	0.00	235,772.53	14.85
TSS	268.51	423.69	0.00	545.74	228.26	2,785.18	60.83	0.00	4,312.20	0.27
FECAL COLIFORM	140,557.64	135,732.71	0.00	327,822.63	323,496.37	0.00	5,069.02	0.00	932,678.36	58.74
TOTAL P	1,397.36	2,181.87	0.00	2,822.81	1,199.46	804.61	253.45	1,348.05	10,007.61	0.63
TOTAL N	13,790.91	21,818.72	0.00	27,851.75	11,815.58	7,040.31	3,041.41	3,081.26	88,439.94	5.57
LEAD	1,981.87	4,490.60	0.00	903.30	599.73	30.95	101.38	38.52	8,146.34	0.51
ZINC	1,397.36	3,551.88	0.00	677.48	295.39	170.21	101.38	38.52	6,232.21	0.39
	913.31	2,537.06	0.00	3,763.75	895.12	773.66	5,069.02	1,925.79	15,877.71	
	5.75%	15.98%	0.00%	23.70%	5.64%	4.87%	31.93%	12.13%	100.00%	

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2103 (Lynnhaven - Western Br.)
ESTIMATED ANNUAL NPS LOADS-

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	31,806.08	41,002.53	0.00	88,501.68	32,734.61	27,787.50	4,507.70	0.00	226,340.11	17.36
TSS	250.03	314.10	0.00	686.24	229.95	2,223.00	31.82	0.00	3,735.14	0.29
FECAL COLIFORM	130,881.18	100,625.47	0.00	412,219.04	325,903.29	0.00	2,651.59	0.00	972,280.58	74.55
TOTAL P	1,301.16	1,617.53	0.00	3,549.53	1,208.39	642.20	132.58	974.90	9,426.28	0.72
TOTAL N	12,841.49	16,175.31	0.00	35,022.05	11,903.50	5,619.25	1,590.95	2,228.34	85,380.89	6.55
LEAD	1,845.43	3,329.10	0.00	1,135.85	604.19	24.70	53.03	27.85	7,020.17	0.54
ZINC	1,301.16	2,633.19	0.00	851.89	297.59	135.85	53.03	27.85	5,300.56	0.41
1985 LAND USE										
Acres:	850.43	1,880.85	0.00	4,732.71	901.78	617.50	2,651.59	1,392.71	13,041.67	
Percent:	6.52%	14.42%	0.00%	36.29%	6.91%	4.73%	20.33%	10.68%	100.00%	

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2201 (Little Creek)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	26,728.66	22,820.02	0.00	29,878.11	21,296.85	45,079.20	3,960.49	0.00	149,763.33	18.17
TSS	210.11	174.81	0.00	231.68	149.61	3,606.34	27.96	0.00	4,400.50	0.53
FECAL COLIFORM	109,987.71	56,003.27	0.00	139,164.90	212,029.77	0.00	2,329.70	0.00	519,515.34	63.03
TOTAL P	1,093.45	900.24	0.00	1,198.32	786.16	1,041.83	116.49	675.37	5,811.86	0.71
TOTAL N	10,791.52	9,002.39	0.00	11,823.42	7,744.31	9,116.02	1,397.82	1,543.71	51,419.19	6.24
LEAD	1,550.83	1,852.82	0.00	383.46	393.08	40.07	46.59	19.30	4,286.16	0.52
ZINC	1,093.45	1,465.51	0.00	287.60	193.61	220.39	46.59	19.30	3,326.43	0.40
1985 LAND USE										
Acres:	714.67	1,046.79	0.00	1,597.76	586.69	1,001.76	2,329.70	964.82	8,242.19	
Percent:	8.67%	12.70%	0.00%	19.39%	7.12%	12.15%	28.27%	11.71%	100.00%	

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2202 (Little Creek)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	11,924.62	34,900.06	0.00	19,048.94	5,830.51	0.00	1,080.86	0.00	72,784.98	17.79
TSS	93.74	267.35	0.00	147.71	40.96	0.00	7.63	0.00	557.39	0.14
FECAL COLIFORM	49,069.48	85,649.22	0.00	88,725.29	58,048.07	0.00	635.80	0.00	282,127.85	68.96
TOTAL P	487.83	1,376.79	0.00	764.00	215.23	0.00	31.79	249.23	3,124.87	0.76
TOTAL N	4,814.48	13,767.91	0.00	7,538.08	2,120.18	0.00	381.48	569.68	29,191.82	7.14
LEAD	691.88	2,833.63	0.00	244.48	107.62	0.00	12.72	7.12	3,897.44	0.95
ZINC	487.83	2,241.29	0.00	183.36	53.00	0.00	12.72	7.12	2,985.31	0.73
1985 LAND USE										
Acres:	318.84	1,600.92	0.00	1,018.66	160.62	0.00	635.80	356.05	4,090.89	
Percent:	7.79%	39.13%	0.00%	24.90%	3.93%	0.00%	15.54%	8.70%	100.00%	

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2203 (Little Creek)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	8,867.91	13,500.09	0.00	23,330.12	19,188.33	0.00	485.71	0.00	65,372.15	19.99
TSS	69.71	103.42	0.00	180.90	134.79	0.00	3.43	0.00	492.25	0.15
FECAL COLIFORM	36,491.23	33,130.95	0.00	108,665.96	191,037.49	0.00	285.71	0.00	369,611.33	113.02
TOTAL P	362.78	532.57	0.00	935.70	708.33	0.00	14.29	246.39	2,800.05	0.86
TOTAL N	3,580.36	5,325.72	0.00	9,232.24	6,977.57	0.00	171.43	563.17	25,850.49	7.90
LEAD	514.53	1,096.11	0.00	299.42	354.16	0.00	5.71	7.04	2,276.98	0.70
ZINC	362.78	866.98	0.00	224.57	174.44	0.00	5.71	7.04	1,641.52	0.50
1985 LAND USE										
Acres:	237.11	619.27	0.00	1,247.60	528.60	0.00	285.71	351.98	3,270.27	
Percent:	7.25%	18.94%	0.00%	38.15%	16.16%	0.00%	8.74%	10.76%	100.00%	

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2301 (Rudee Basin)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	3,599.00	4,530.04	0.00	532.39	11,675.17	0.00	980.36	0.00	21,316.96	15.27
TSS	28.29	34.70	0.00	4.13	82.02	0.00	6.92	0.00	156.06	0.11
FECAL COLIFORM	14,809.80	11,117.30	0.00	2,479.74	116,237.08	0.00	576.68	0.00	145,220.60	104.02
TOTAL P	147.23	178.71	0.00	21.35	430.98	0.00	28.83	115.66	922.77	0.66
TOTAL N	1,453.07	1,787.08	0.00	210.68	4,245.52	0.00	346.01	264.37	8,306.72	5.95
LEAD	208.82	367.81	0.00	6.83	215.49	0.00	11.53	3.30	813.79	0.58
ZINC	147.23	290.92	0.00	5.12	106.14	0.00	11.53	3.30	564.25	0.40
1985 LAND USE										
Acres:	96.23	207.80	0.00	28.47	321.63	0.00	576.68	165.23	1,396.04	
Percent:	6.89%	14.88%	0.00%	2.04%	23.04%	0.00%	41.31%	11.84%	100.00%	

LITTLE CREEK/LYNNHAVEN DRAINAGE BASIN 2302 NPS (Rudee Basin)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	2,171.07	1,377.76	0.00	1,077.31	118.70	0.00	980.17	0.00	5,725.01	6.37
TSS	17.07	10.55	0.00	8.35	0.83	0.00	6.92	0.00	43.73	0.05
FECAL COLIFORM	8,933.89	3,381.20	0.00	5,017.83	1,181.78	0.00	576.57	0.00	19,091.27	21.23
TOTAL P	88.82	54.35	0.00	43.21	4.38	0.00	28.83	98.43	318.02	0.35
TOTAL N	876.55	543.52	0.00	426.31	43.16	0.00	345.94	224.99	2,460.49	2.74
LEAD	125.97	111.86	0.00	13.83	2.19	0.00	11.53	2.81	268.19	0.30
ZINC	88.82	88.48	0.00	10.37	1.08	0.00	11.53	2.81	203.09	0.23
1985 LAND USE										
Acres:	58.05	63.20	0.00	57.61	3.27	0.00	576.57	140.62	899.32	
Percent:	6.45%	7.03%	0.00%	6.41%	0.36%	0.00%	64.11%	15.64%	100.00%	

ALBEMARLE WATERSHED
ESTIMATED TOTAL ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL
BOD	307,025.02	103,527.55	0.00	201,613.15	32,281.95	2,728,436.94	389,716.99	0.00	3,762,601.60
TSS	2,413.51	793.08	0.00	1,563.31	226.77	218,274.96	2,750.94	0.00	226,022.57
FECAL COLIFORM	1,263,399.73	254,069.90	0.00	939,064.47	321,396.63	0.00	229,245.29	0.00	3,007,176.02
TOTAL P	12,560.11	4,084.11	0.00	8,086.09	1,191.68	63,057.21	11,462.26	26,448.46	126,889.93
TOTAL N	123,959.30	40,841.14	0.00	79,782.74	11,738.89	551,750.58	137,547.17	60,453.63	1,006,073.46
LEAD	17,814.02	8,405.68	0.00	2,587.55	595.84	2,425.28	4,584.91	755.67	37,168.93
ZINC	12,560.11	6,648.56	0.00	1,940.66	293.47	13,339.03	4,584.91	755.67	40,122.41
1985 LAND USE									
Acres:	8,209.23	4,748.97	0.00	10,781.45	889.31	60,631.93	229,245.29	37,783.52	352,289.70
Percent:	2.33%	1.35%	0.00%	3.06%	0.25%	17.21%	65.07%	10.73%	100.00%

ALBEMARLE DRAINAGE BASIN 3101 (Back Bay)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	17,416.06	15,637.14	0.00	37,494.25	937.27	586,702.80	38,231.54	0.00	696,419.05	10.32
TSS	136.91	119.79	0.00	290.73	6.58	46,936.22	269.87	0.00	47,760.10	0.71
FECAL COLIFORM	71,666.61	38,375.55	0.00	174,638.98	9,331.35	0.00	22,489.14	0.00	316,501.64	4.69
TOTAL P	712.48	616.88	0.00	1,503.78	34.60	13,559.35	1,124.46	20,103.31	37,654.86	0.56
TOTAL N	7,031.62	6,168.78	0.00	14,837.30	340.82	118,644.34	13,493.48	45,950.43	206,466.78	3.06
LEAD	1,010.50	1,269.62	0.00	481.21	17.30	521.51	449.78	574.38	4,324.31	0.06
ZINC	712.48	1,004.22	0.00	360.91	8.52	2,868.32	449.78	574.38	5,978.61	0.09
1985 LAND USE										
Acres:	465.67	717.30	0.00	2,005.04	25.82	13,037.84	22,489.14	28,719.02	67,459.83	
Percent:	0.69%	1.06%	0.00%	2.97%	0.04%	19.33%	33.34%	42.57%	100.00%	

ALBEMARLE DRAINAGE BASIN 3102 (North Landing River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	162,287.76	48,720.82	0.00	109,038.80	31,344.69	1,275,357.15	75,425.53	0.00	1,702,174.75	18.94
TSS	1,275.74	373.23	0.00	845.49	220.19	102,028.57	532.42	0.00	105,275.63	1.17
FECAL COLIFORM	667,809.81	119,567.15	0.00	507,875.92	312,065.29	0.00	44,367.96	0.00	1,651,686.12	18.37
TOTAL P	6,639.04	1,922.01	0.00	4,373.21	1,157.08	29,474.92	2,218.40	2,740.11	48,524.78	0.54
TOTAL N	65,522.60	19,220.14	0.00	43,149.04	11,398.07	257,905.56	26,620.78	6,263.10	430,079.29	4.78
LEAD	9,416.16	3,955.77	0.00	1,399.43	578.54	1,133.65	887.36	78.29	17,449.20	0.19
ZINC	6,639.04	3,128.86	0.00	1,049.57	284.95	6,235.08	887.36	78.29	18,303.16	0.20
1985 LAND USE										
Acres:	4,339.25	2,234.90	0.00	5,830.95	863.49	28,341.27	44,367.96	3,914.44	89,892.26	
Percent:	4.83%	2.49%	0.00%	6.49%	0.96%	31.53%	49.36%	4.35%	100.00%	

ALBEMARLE DRAINAGE BASIN 3103 (Northwest River)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	111,814.41	19,202.53	0.00	36,252.57	0.00	353,860.74	89,531.59	0.00	610,661.83	8.99
TSS	878.97	147.10	0.00	281.10	0.00	28,308.86	631.99	0.00	30,248.02	0.45
FECAL COLIFORM	460,113.29	47,125.48	0.00	168,855.54	0.00	0.00	52,665.64	0.00	728,759.95	10.73
TOTAL P	4,574.23	757.53	0.00	1,453.98	0.00	8,178.11	2,633.28	1,086.09	18,683.23	0.28
TOTAL N	45,144.32	7,575.31	0.00	14,345.94	0.00	71,558.51	31,599.38	2,482.50	172,705.95	2.54
LEAD	6,487.63	1,559.10	0.00	465.27	0.00	314.54	1,053.31	31.03	9,910.89	0.15
ZINC	4,574.23	1,233.19	0.00	348.96	0.00	1,729.99	1,053.31	31.03	8,970.70	0.13
1985 LAND USE										
Acres:	2,989.69	880.85	0.00	1,938.64	0.00	7,863.57	52,665.64	1,551.56	67,889.95	
Percent:	4.40%	1.30%	0.00%	2.86%	0.00%	11.58%	77.58%	2.29%	100.00%	

ALBEMARLE DRAINAGE BASIN 3201 (Dismal Swamp)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	13,606.12	8,193.53	0.00	5,944.54	0.00	101,418.30	122,466.78	0.00	251,629.27	3.20
TSS	106.96	62.77	0.00	46.09	0.00	8,113.46	864.47	0.00	9,193.75	0.12
FECAL COLIFORM	55,988.82	20,107.98	0.00	27,688.22	0.00	0.00	72,039.28	0.00	175,824.29	2.24
TOTAL P	556.61	323.23	0.00	238.42	0.00	2,343.89	3,601.96	2,272.15	9,336.27	0.12
TOTAL N	5,493.38	3,232.31	0.00	2,352.39	0.00	20,509.03	43,223.57	5,193.49	80,004.17	1.02
LEAD	789.45	665.25	0.00	76.29	0.00	90.15	1,440.79	64.92	3,126.85	0.04
ZINC	556.61	526.19	0.00	57.22	0.00	495.82	1,440.79	64.92	3,141.55	0.04
1985 LAND USE										
Acres:	363.80	375.85	0.00	317.89	0.00	2,253.74	72,039.28	3,245.93	78,596.49	
Percent:	0.46%	0.48%	0.00%	0.40%	0.00%	2.87%	91.66%	4.13%	100.00%	

ALBEMARLE DRAINAGE BASIN 3202 (Dismal Swamp)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	1,408.48	7,204.68	0.00	8,741.50	0.00	219,271.95	25,639.40	0.00	262,266.02	12.61
TSS	11.07	55.19	0.00	67.78	0.00	17,541.76	180.98	0.00	17,856.79	0.86
FECAL COLIFORM	5,795.87	17,681.22	0.00	40,715.77	0.00	0.00	15,082.00	0.00	79,274.86	3.81
TOTAL P	57.62	284.22	0.00	350.59	0.00	5,067.62	754.10	10.50	6,524.65	0.31
TOTAL N	568.67	2,842.21	0.00	3,459.20	0.00	44,341.66	9,049.20	24.00	60,284.95	2.90
LEAD	81.72	584.97	0.00	112.19	0.00	194.91	301.64	0.30	1,275.73	0.06
ZINC	57.62	462.69	0.00	84.14	0.00	1,072.00	301.64	0.30	1,978.38	0.10
1985 LAND USE										
Acres:	37.66	330.49	0.00	467.46	0.00	4,872.71	15,082.00	15.00	20,805.32	
Percent:	0.18%	1.59%	0.00%	2.25%	0.00%	23.42%	72.49%	0.07%	100.00%	

ALBEMARLE DRAINAGE BASIN 3203 (Dismal Swamp)
ESTIMATED ANNUAL NPS LOADS

PARAMETER	COMMERCIAL/ INSTITUTIONAL	LIGHT INDUSTRY	HEAVY INDUSTRY	LOW DENSITY RESIDENTIAL	HIGH DENSITY RESIDENTIAL	AGRICULTURAL	OPEN AND UNDEVELOPED	WATER	TOTAL	POUNDS PER ACRE
BOD	492.18	4,568.84	0.00	4,141.49	0.00	191,826.00	38,422.16	0.00	239,450.68	8.66
TSS	3.87	35.00	0.00	32.11	0.00	15,346.08	271.22	0.00	15,688.28	0.57
FECAL COLIFORM	2,025.32	11,212.53	0.00	19,290.04	0.00	0.00	22,601.27	0.00	55,129.16	1.99
TOTAL P	20.13	180.24	0.00	166.10	0.00	4,433.31	1,130.06	236.30	6,166.15	0.22
TOTAL N	198.72	1,802.39	0.00	1,638.88	0.00	38,791.48	13,560.76	540.11	56,532.34	2.04
LEAD	28.56	370.96	0.00	53.15	0.00	170.51	452.03	6.75	1,081.96	0.04
ZINC	20.13	293.41	0.00	39.86	0.00	937.82	452.03	6.75	1,750.00	0.06
1985 LAND USE										
Acres:	13.16	209.58	0.00	221.47	0.00	4,262.80	22,601.27	337.57	27,645.85	
Percent:	0.05%	0.76%	0.00%	0.80%	0.00%	15.42%	81.75%	1.22%	100.00%	